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2
A Summary of Current Program 7/1/65

and Preliminary Report of Progress

for 7/1/64 to 6/30/65

MARKET QUALITY

RESEARCH DIVISION

of the

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

and related work of the

STATE AGRICULTURAL EXPERIMENT STATIONS

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CURRENT SERIAL RECORDS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1964, and June 30, 1965. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Market Quality Research Division, Agricultural Research Service, U. S. Department of Agriculture.

UNITED STATES DEPARTMENT OF AGRICULTURE

Hyattsville, Maryland 20781

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INTRODUCTION

Market Quality research deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of agricultural commodities, and the development of new methods and devices for evaluation of quality.

The Market Quality Research Division is a part of the Agricultural Research Service. It is headquartered at Hyattsville, Maryland. The greatest concentration of its scientific personnel is at Beltsville, Maryland. Here the Instrumentation Research Laboratory, the Post-Harvest Physiology Pioneering Research Laboratory, and field stations of the Field Crops and Animal Products Research Branch, and the Horticultural Crops Research Branch are located. Additional personnel are located in Washington, D. C. There are also 21 field stations located throughout the country including two Terminal Market Laboratories; nine of these are located at State Universities or branch Experiment Stations. Total research effort including research contracts amounts to approximately 140 professional man years.

Although a large variety of excellent quality fresh agricultural products are retailed at reasonable prices throughout the year there is need for further research on methods to reduce spoilage and waste during storage, transportation and distribution and to improve methods for evaluation of quality. Stored product insects and market diseases still take heavy tolls of some lots of produce. Also there is urgent need for new methods of control that will not create health hazards due to pesticide residues. There is increasing need for automated objective methods of quality evaluation to make possible rapid reliable grading and inspection of large quantities of produce under modern packing and handling conditions.

As might be expected an appreciable amount of Market Quality research is related to the effective performance of the Service Divisions of the Consumer and Marketing Service responsible for standardization, inspection, and grading of agricultural commodities. The Division also works closely with industry and other Government Agencies on various problems relating to agricultural commodities in the marketing channels. Specific examples of Market Quality research accomplishments over the past five years are:

Insect-Resistant Packages Do Well Under Commercial Conditions. Insect-resistant multiwall paper bags kept cornmeal free of insect infestation from the mill in Illinois to the port of destination in Brazil. The new bags incorporated a repellent treatment on the outside with improved construction and closure features. Cornmeal was also shipped in conventional bags, became infested and had to be fumigated before loading aboard ship. Upon arrival in Brazil after three weeks in transit, the meal in over half of the conventional bags had again become insect-infested.

Sweetpotato Quality. Research conducted in North Carolina in cooperation with the State Experiment Station and the Transportation and Facilities Research Division of ARS, has substantially improved handling practices and storage facilities, and reduced decay of sweetpotatoes in the markets. This has been accomplished through introduction of palletized-crate handling for harvest, curing, and storage; adaptation of thermostatically-controlled ventilation and air circulation systems for cooling in storage and floor trench heating systems for prevention of chilling injury, and development of post-storage fungicidal treatments for reduction of decay during transit and terminal marketing. The average annual on-farm value of commercial sweetpotatoes in 19 states is about 70 million dollars.

Effect of Various Factors on Moisture Absorption, Retention and Loss by Fryer Chickens. Absorption, retention and loss of moisture from chicken fryers during commercial processing, transportation and storage was found to be influenced by (a) type of cuts used during evisceration, (b) temperature of prechilling, (c) time of prechilling, (d) carcass weight, (e) washing, (f) removal of neck before chilling, (g) time of vat chilling, (h) type of chilling system, (i) phosphates added to chill water, (j) NaCl added to chill water, (k) initial pH of chill water, (l) air agitation in chiller, and (m) combination of continuous chilling with subsequent phosphate soak. These findings were utilized in promulgating many new regulations which defined procedures and tolerances related to moisture added or lost during processing and marketing of poultry. They are also available to the poultry processing industry through government, technical and trade journal publications. They assist the processor in determining the effect on product moisture of modifications in techniques or equipment.

Reduction of Soft Rot in Bell Peppers. Research conducted in Texas has developed important information on the origin and control of soft rot which causes substantial losses from decay during each marketing season. In the course of studies to develop decay control treatments, research revealed that commercially-waxed peppers developed several times as much soft rot during subsequent holding as unwaxed peppers. Further investigation proved that contaminated brushes in the waxer were spreading soft rot inoculum to originally non-infected peppers. The research demonstrated that frequent disinfection of the brushes with chlorine solution would greatly reduce

decay. Other factors contributing to postharvest decay were broken stems, contaminated hydrocoolers, and high water content of the pod tissues. These findings are now being applied in the South Texas pepper industry. In the 15 states with important commercial production of green peppers the on-farm value is about 30 million dollars.

Almost Complete Insect Control in a Tobacco Warehouse. A tobacco warehouse was fumigated in the spring of 1964. Dichlorvos aerosol applications have been made daily since then during the active insect seasons. Only 11 cigarette beetles have been trapped in that warehouse up till July 1965. Trap counts in warehouses where the best previously available commercial control measures were used may run as high as 2 or 3 thousand per week. Dichlorvos is being used extensively in tobacco warehouses where it is giving good control of cigarette beetles and has virtually eliminated the tobacco moth as a pest. The use of this material is relatively new, however, and further research is continuing.

These examples of research accomplishments illustrate the variety of work engaged in and its potential value in prevention of damage to the commodity and loss of quality. The savings made by this kind of research, benefiting both the consumer and the producer, amounts to many millions of dollars each year. The year-round supply of a great variety of wholesome, nutritious food, some of it extremely perishable, is tangible evidence of the progress in the handling, transportation and storage of food. The research of the U. S. Department of Agriculture in this field over the past 50 years has made a major contribution to the practices now in use in the marketing of agricultural commodities.

AREA 1

CITRUS AND SUBTROPICAL FRUIT - MARKET QUALITY

Problem. Research is needed to develop better objective indices for measurement of quality of citrus and other subtropical fruits. This would result in more meaningful grades and standards which could be better enforced. Instrumentation and automatic devices for quality sorting on a commercial basis might be possible. Decays and fruit soilage present serious problems in both domestic and export markets. Much research is needed to relate mechanical harvesting, handling practices, packaging, precooling and transit refrigeration to wastage, and to develop effective treatments for decay reduction. There is need for further research on controlled atmosphere storage for citrus and other subtropical fruits. Problems which are sometimes distinct and sometimes interrelated exist in each of the geographical areas but which require biological research in the separate production areas for solution.

USDA PROGRAM

The Department has a continuing program involving largely applied research performed by horticulturists, plant physiologists, plant pathologists, and food technologists. Research is conducted in the producing areas of California, Florida and Texas. Market studies are made in Belle Mead, New Jersey and Chicago. P.L. 480 grants are operative for research in Colombia on avocado and papaya fruits; for studies in India on identification and mode of infection of fungi causing postharvest rots of tropical fruits; in Spain on detection of additives in citrus juices; in Germany on the antimicrobial action of biphenyl; and in Israel on maturation and ripening of avocados. A contract study on citrus fruit quality as related to mechanical harvesting is under way at the Citrus Experiment Station, Lake Alfred, Florida.

Total federal professional man-years devoted to this area is 11.8. Of this 1.9 is devoted to objective measurement of quality; 1.7 to quality maintenance during handling (mechanical harvesting); 2.5 to quality maintenance in storage; 1.0 to quality maintenance during transportation; 1.0 to postharvest physiology; and 3.7 to postharvest disease control. P.L. 480 projects in this area involve \$64,145 equivalent over a 3-year period in Colombia; \$29,732 equivalent over a 5-year period in India; \$56,163 equivalent over a 4-year period in Spain; \$77,138 equivalent over a 5-year period in West Germany and a 5-year \$83,620 equivalent project in Israel.

Projects terminated during this period included preharvest infection as related to postharvest decay (MQ 2-24) and seasonal changes as related to metabolic activity of oranges (MQ 3-20).

CURRENT PROGRAM OF STATE EXPERIMENT STATIONS

Research on market quality of citrus and subtropical fruit is receiving special attention in three States. California researchers are investigating the effect of storage temperature and length of holding upon the physical and chemical characteristics of citrus fruit. Other research in California is concerned with factors influencing market quality of mature avocado fruits. Research in Florida is designed to determine the relation of physical measurements of citrus fruit to volume of juice and other internal qualities. Florida is also investigating the forced air precooling of citrus fruit.

Fundamental studies on the respiration of papayas and on the browning of lychee pericarp are in progress in Hawaii. These researchers are also interested in factors affecting the keeping quality of Hawaiian fruit in relation to quarantine sterilization. Studies of factors contributing to improved processing and utilization of Macadamia nuts are also receiving attention.

Disease investigations include studies to reduce fruit and vegetable decays during storage, transit, and marketing by postharvest applications of fungicides.

Total market quality research effort on citrus and subtropical fruit at the State stations is approximately 5.7 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Relation of Physical Properties to Market Quality of Oranges and Grapefruit. Light transmittance techniques were found to have good potential for sorting Hamlin oranges for degreening. These readings showed a close relationship between the color of individual fruit and the time required for degreening. Keeping the fruit in the degreening room only long enough to degreen it should reduce rind breakdown and decay during subsequent marketing and permit more efficient use of degreening facilities. (MQ 3-20)
2. Aromatic Polynuclear Hydrocarbons in Citrus Fruits. A method was developed for the cleanup and screening of citrus extracts for residues of polynuclear aromatic hydrocarbons. Benzo(a)pyrene, 3-methylcholanthrene, and dibenz(a,h)anthracene could be detected at concentrations as low as 0.01 ppm. None of the three polynuclear hydrocarbons was found in citrus fruit samples from widely different growing areas or following the usual packing house treatments. (MQ 3-46)
3. Seasonal Changes in Florida Persian Limes. Limes originating from spring blooms developed more rapidly and contained a higher juice content than those from fall blooms. Citric acid content was higher in small limes than in large

ones and was higher in fruits picked during the spring and summer than those picked during the fall and winter. A correlation exists among low juice content, dark green peel, and thick rind. (MQ 3-53)

4. The Detection of Additives in Citrus Juices. Under this P.L. 480 project in Spain a chromatographic method has been developed for detecting synthetic coloring in orange juice that is rapid and practical. Important findings include identification of trace constituents in commercial sucrose and citric acid. This will assist in detecting fraud or excessive additions of these materials to processed orange juice. Progress made in analytical methods also will be helpful in determining composition of unaltered citrus juices. (E25-AMS-6k)

B. Quality maintenance in handling and packaging

1. Citrus Fruit Quality as Related to Mechanical Harvesting. In research underway on contract at the Florida Experiment Station, two methods of mechanical fruit removal are being evaluated for effects on fruit quality, particularly physical damage and postharvest decay. Of the orange varieties tested, the Pineapple sustained the most physical damage and Valencia the least during mechanical shaker harvesting. Fruit removal by high velocity air has caused greater damage than shaker methods so far. Damage by either method has so far been severe enough to prevent their use for fresh market fruit. Limited intramural research in Florida and California has indicated some possibilities for harvesting aids and fruit conveyor systems which increase hand picking speed. Treatment of mechanically injured fruit with approved chemicals has also indicated some promise of holding postharvest decay within commercially acceptable limits. (MQ 2-65)

C. Quality maintenance in storage

1. Controlled Atmosphere Storage of Florida Valencia Oranges. Valencia oranges held for 3 months in CA storage at 32° with 15% O₂ and 0% CO₂, plus 1 week in air at 70° F. had good flavor, were free of rind breakdown, and had the least amount of decay. At 50°, the various controlled atmospheres did not deter development of decay. The respiration rate of the rind of Valencia oranges held for 3 months at 50° F. in less than 1 percent oxygen and carbon dioxide was 10 percent of that of fruit held in air at the same temperature. At 32° in similar CA conditions the rind had a respiration rate of about 30 percent of that of fruit held in air. Under this atmosphere, severe rind browning and excessive decay developed. The respiration rate of the rind of oranges stored at 32° in 15% O₂ - 0% CO₂ was slightly higher than that of fruit stored in air. (MQ 2-110 and MQ 2-79)

2. Controlled Atmosphere Storage of California Oranges. Washington Navel oranges harvested January 11, 1965, were stored 10 to 11 weeks in a number of different CA atmospheres at 36° and 42° F. Five percent carbon dioxide tended to increase the Penicillium decay, especially in fruit held at 36°. None of the fruit in CA had as good flavor as the controls. The flavor tended to worsen with a decrease in oxygen concentration. (MQ 2-98)

3. Controlled Atmosphere Storage of Texas Grapefruit. Two controlled atmospheres, 0.75 and 2.5% oxygen, each with 5% carbon dioxide, were superior to other modified atmospheres or air for control of rind pitting, maintenance of harvesttime peel and pulp color and dessert quality of Texas grapefruit. November-harvested fruit after 16 weeks' storage in either of these two atmospheres, plus 18 days in air at 45°, plus 7 days at 70°, or a total of 20 weeks from harvest, had better external and internal appearance than "tree stored" fruit. Total decay in the early-season fruit held in these two atmospheres amounted to less than 2% after 130 days at 45°. In contrast, January fruit held in similar atmospheres developed 30% decay after only 84 days' storage. (MQ 2-98)

4. Controlled Atmosphere Storage of Florida Avocados, Mangos, and Limes. After 60 days in CA storage at 40° F. Lula avocados were mostly in excellent condition. The most satisfactory atmosphere was 1% O₂ plus 7% CO₂.

After 6 weeks in CA storage at 55°, Keitt mangos were firm; those stored in air were soft after 2 weeks.

After 30 days in CA storage at 50°, limes were greener and contained less citric acid and juice than those stored in air. (MQ 2-110)

5. Postharvest Changes in Papayas and Avocados. Research on the isolation and purification of avocado oils is continuing under this P.L. 480 project in Colombia but results have not yet been reported. Chemical changes in papayas during maturation indicate a relationship in mature-green fruit between peak concentration of ascorbic acid and maximum difference in concentration of total and reducing sugars. This relationship may prove to be a significant index for determining optimum harvest maturity. (S5-AMS-3(a))

D. Quality maintenance during transportation

1. Thermal Conductivity in Florida Citrus Fruit. Little difference was noted in the thermal conductivity values of Marsh grapefruit harvested in October, January, and May. The mean "k" value for the rind was 1.655 BTU/hr/ft²/°F/in. and for the juice vesicles 3.25 BTU/hr/ft²/°F/in. The diffusivity values of Marsh Seedless grapefruit ranged from .0058 to .0037 sq.ft/hr. (MQ 2-53)

E. Postharvest disease control

1. Control of Decay of California Citrus Fruits. Warm (110° F. or higher) 2,6-dichloro-4-nitroaniline (Botran) solution at 1% concentration and 11.5 to 12.0 pH substantially reduced decay of lemons during storage caused by Penicillium digitatum (green mold) infections. Botran did not control decay quite as well as 0.5% sodium-o-phenylphenate (SOPP) on fruit inoculated before treatment but was better than SOPP on fruit inoculated after treatment. SOPP treatment is not recommended for lemons going into storage at the shipping point because residues in the rind may lead to a build-up of biphenyl-resistant strains of Penicillium. (MQ 2-24)

2. Control of Decay of Florida Citrus Fruit. One percent 2-aminobutane acetate was more effective than SOPP on all varieties of citrus tested. Ten other new fungicides tested were not effective in reducing decay of oranges. Hot water treatment (128° F. - 5 min.) was as good or better than SOPP.

Early harvesting of Robinson tangerines, with extended use of ethylene gas, greatly increased stem-end and side decays.

In simulated mechanical harvesting tests, Hamlin and Pineapple oranges, Dancy tangerines, and Marsh Seedless grapefruit increased in mechanical injury and subsequent decay with increase in maturity, while Valencia oranges decreased. Blossom-end bruising of grapefruit increased from 0 in October to more than 50 percent in May. Prompt use of SOPP effectively reduced the incidence of decay. (MQ 2-65)

3. Materials Affecting Germination and Growth of Decay Organisms. 1,2-cyclohexanediamine tetraacetic acid, a chelating compound effective in binding calcium ions, reduced green mold decay in oranges but not stem-end rot. Extracts of flavedo of oranges induced germination of *Penicillium* spores at a pH range of 2.5-10. Chloride ion and potassium phthalate were inhibitory when added to synthetic medium. (MQ 2-100)

4. Postharvest Diseases of Tropical Fruits. Isolation and identification of causal organisms of diseases of mango, guava, banana, papaya, and sapodilla is being continued under this P.L. 480 project in India. Isolations from harvested fruits and from various plant parts in the field have confirmed earlier evidence that much of the postharvest decay in these fruits is caused by organisms involved in field diseases. Several previously unreported organisms have been identified as causal organisms in postharvest decays. Five well illustrated manuscripts on various findings in this study have been submitted for publication. (A7-AMS-6(k))

5. Antimicrobial Action of Biphenyl. This P.L. 480 project was initiated in Germany during this reporting period. An extensive review of related literature has been completed and research is underway on the effects of biphenyl vapor and solutions on sporulation and growth of *Penicillium* spp. and *Trichoderma lignorum*. (E10-AMS-3)

6. Ethylene Production by *Penicillium digitatum*. The use of sporulating mats in replacement culture studies of ethylene production of *Penicillium digitatum* proved to be a very dependable and convenient technique with low variability between duplicates. Replacement with C (carbon) - free medium of various pH levels gave maximum ethylene production at ca. pH 6. In the presence of a C source (glucose, sucrose, or citric acid), the optimum pH for ethylene production gradually shifted with time from ca. pH 6 to ca. pH 4, the point of maximum growth and respiration. Comparisons of 0.1 M C sources for ethylene production at pH 4 showed that glucose was more effective than citrate, sucrose, glycerol, pyruvate, or malate. The inability of metabolic inhibitors to block ethylene production suggests that *P. digitatum* synthesizes ethylene by several pathways, possibly including the Krebs cycle. (MQ 2-60)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

Sanchez, J., Alberola, J. and Garcia, I. 1964. Deteccion de adulteraciones en zumos citricos. II. Identificacion de acidos en variedades de naranjas. Agroquimica y Tecnologia de Alimentos 4(3):371. (E25-AMS-6(k))

Quality Maintenance During Transportation

Redit, W. H. 1964. Insulating properties of citrus gift packages exposed to freezing temperatures. The Citrus Industry 45(12):9-11, 13. (MQ 2-53)

Postharvest Disease Control

Hatton, T. T., Jr., and Wm. F. Reeder. 1965. Hot water as a commercial control of mango anthracnose. Proc. Caribbean Region Amer. Soc. Hort. Sci. 8:76-84. (MQ 2-68)

Smoot, John J., and Currie F. Melvin. 1965. Reduction of citrus decay by hot water treatment. Plant Disease Reporter 49:463-467. (MQ 2-65)

Williamson, D. and R. N. Tandon. 1965. Post infection changes in the carbohydrate contents of banana fruits caused by Botryodiplodia theobromae Pat. Die Naturwissenschaften 52 Jahrgang Heft 7, S. 166. (A7-AMS-6)

Tandon, R. N., M. P. Srivastava, S. N. Bhargava and A. K. Ghosh. 1965. Studies on fungal diseases of some tropical fruits. V. Some unrecorded fungi. 34th Annual Session on the National Academy of Sciences, India. Section B, pp. 58-59. (A7-AMS-6)

Srivastava, M. P., R. N. Tandon, S. N. Bhargava and A. K. Ghosh. 1965. Studies on fungal diseases of some tropical fruits. III. Some postharvest diseases of mango. Proceedings of the National Academy of Sciences, India. Section B, Vol. XXXV, Part 1, pp. 69-75. (A7-AMS-6)

AREA 2

DAIRY PRODUCTS - MARKET QUALITY

Problem. Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage life of dairy products. Several kinds of insects and mites contaminate or damage dairy products during processing, storage, and distribution. To maintain quality of these products in marketing channels, research is needed on the factors influencing keeping quality; on developing new and improved objective quality tests for bulk milk and other products; on developing safe and effective procedures for preventing or controlling insect and mite infestations; and to find improved and simplified detection methods for antibiotic and pesticide residues in dairy products.

USDA PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. At Beltsville, studies of the shelf-life of canned butteroil are continuing, work on chlorinated pesticide residues in dairy products is being expanded to cover other animal products and livestock feeds and forages; and new work has been started on estimation of moisture dispersion in butter and improving the direct microscopic count for bacteria in milk. Contract work under line project MQ 3-14(C) at the University of California at Davis on estimation of the protein content of milk by dye-binding has been completed. A contract under line project MQ 3-44(C) with the University of Minnesota on estimation of the quality of manufacturing milk has also been completed in the past year. Reports on both contract studies are being prepared for publication. The Federal scientific effort devoted to research in this program totals approximately 2.0 professional man-years.

There is a continuing program headquartered at Fresno, California, involving basic research in entomology and chemistry, directed toward the prevention of insect and mite infestation and contamination of dairy products in the marketing channels. The Federal effort on this program during the reporting period was 0.5 professional man-year. The entomologist on the program was at the University of Wisconsin during part of the period, doing graduate work under the Division's training program. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dairy products.

On June 1, 1965, a 2-year research contract in the amount of \$49,190 was awarded to the Stanford Research Institute for a study on natural attractants in certain dermestid beetles.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The market quality research program at the State stations deals with the bacteriostatic action of fresh milk and its effects on cultured products; changes in milk quality during transport and storage; the effect of trace amounts of sanitizing agents on flavor and manufacture of dairy products; and developing techniques to predict shelf life of market milk. This includes rapid methods for enumerating psychrophilic micro-organisms.

The program concerns the development of rapid methods for measuring the gross composition of milk. Included in this area of research are efforts to develop methods which are rapid and accurate for protein, solids not fat, and for fat in dairy products such as homogenized chocolate milk.

Another phase of this program has to do with the effects of standardized milk on yield, grade, and quality of cheddar type cheeses; means of improving quality of cottage cheese, concentrated and dried products, butter and ice cream. Other research on quality concerns effects of processing on the flavor and quality of market milk.

One other phase deals with freezing point determination of milk under different management practices and different locations and also acid degree values as an index to rancid flavor in fluid milk.

A total of 10.5 professional man-years is devoted to market quality research on dairy products.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Protein Content. A manuscript for publication as a USDA Technical Bulletin was prepared by the contractor and is now being reviewed and edited.
(MQ 3-14(C))

2. Manufacturing Milk. This project under contract with the University of Minnesota was completed. The final report provides, for the first time, comprehensive data on the quality of manufacturing grade milk and the

interrelationships among four grading methods (standard plate count (SPC), direct microscopic count (DMC), resazurin reduction test (RRT), and methylene blue reduction test (MBRT)) as affected by method of handling, geographical location, season, and other factors. The results showed that the RRT is probably the most suitable for a single grading test to be used to the exclusion of others, since it is inexpensive to run and seems to be less affected by geographical location, etc., than the MBRT or DMC. (MQ 3-44(C))

3. Stability of Anhydrous Butterfat. Samples put in storage in sealed cans at 32°, 70°, and 100° F. were opened after 1 year of storage. As compared to 6 months, the 32° and 70° samples showed more oxidation while little further change was noted in the 100° F. sample. A simpler and more reproducible method of carrying out the thiobarbituric acid test with butteroil was developed. All samples of butteroil appear to be still satisfactory for use after 1 year of storage although a slight oxidized flavor is evident in most. With ghee, a slight oxidized flavor was noted in the sample stored 1 year at 100° F. but samples stored at 70° and 32° F. were still good. (MQ 3-49)

4. Moisture Distribution in Butter. Conductance measurements with a commercial battery operated moisture meter showed that the instrument did not adequately differentiate among samples. A few samples with distinctly lower conductance appeared to keep a little better. (MQ 3-57)

5. Pesticide Residues. It was found that development under UV light of insecticide spots on thin-layer chromatograms could be greatly accelerated by steaming the plates prior to exposure to the light. This also improved sensitivity. Spraying with dilute hydrogen peroxide was helpful in preventing darkening from reaction of silver nitrate in the plate with fatty materials. Both florasil and carbon-celite cleanup procedures were usable with small samples of fat. As little as 0.01-0.02 ug of most common chlorinated insecticides in 0.4 g of fat could be detected on plates developed by the above technique, although because of slight interference from fatty materials, detection was more reliable at 0.05 ug or above. The cleanup and thin-layer chromatography proved satisfactory with poultry products also. (MQ 3-70)

B. Prevention of insect infestation

1. Nonpesticidal Control Methods. The apparatus for aerating insects was redesigned to take up less space, hold a larger number of insects, permit continuous operation, and provide greater efficiency in collecting the natural attractant from a large number of dermestid beetles. The attractant is supplied to the Stanford Research Institute for their contract studies. A new type of highly efficient adsorption column was designed for collecting the attractant, and it may replace the conventional cold-trap method used up till now by other researchers. Progress has been made on developing a quantitative bioassay method to evaluate active fractions separated from the collected material and later on the evaluate the attractiveness of synthesized compounds. (MQ 1-32(C))

2. Improved Pesticidal Control Methods. By developing a new type of exposure cage and fumigation chamber arrangement it was possible to conduct controlled laboratory fumigation tests with methyl bromide against Acarus siro L., a common mite pest of cheese. The dosage in milligrams per liter required to kill 95 percent of the mites during different periods of exposure were: 16.8 for 4 hours, 8.1 for 8 hours, 5.2 for 16 hours, and 3.4 for 24 hours. The tests were conducted at 60° F. and 90 percent relative humidity. (MQ 1-6)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Moats, W. A. 1964. Staining of bacteria in milk for direct microscopic examination. A Review. J. Milk and Food Technol. 27 308-10. (MQ 3-44)

Prevention of Insect Infestation

Burkholder, W. E., and R. J. Dicke. 1964. Detection by ultraviolet light of stored-product insects infected with Mattesia dispora. Jour. Econ. Ent. 57(6): 818-819 (MQ 1-4)

AREA 3

DECIDUOUS FRUIT AND TREE NUTS - MARKET QUALITY

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Practical objective measurements of quality would greatly assist in standardization and grading procedures, and the development of instrumentation for this purpose increases the chance for automatic quality sorting on a commercial basis. Additional information is needed on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Continued research is needed with transportation equipment and services as affecting ultimate quality of the product in the market. Dried fruits and tree nuts are subject to insect infestation while drying in the field, during storage while they await processing, in the processing plant, and in marketing channels until they reach the final consumer. Research is needed to develop more effective measures for preventing insect infestation all along this line. Emphasis must be given to finding methods that will avoid both insect contamination and pesticide residues.

USDA PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, and food technologists. The research includes definition, measurement, and maintenance of quality during the period between harvest and consumption. Locations include Beltsville, Maryland; Wenatchee, Washington; Fresno, California; Raleigh, North Carolina; Chicago, Illinois; and Belle Mead, New Jersey. Cooperative agreements and limited contributed funds are in effect with the California Strawberry Advisory Board. P.L. 480 supported research is nearing completion in England on the effects of modified atmospheres on the physiological processes of apples; underway in Finland on fungicide residues and postharvest effects on fruits as related to time and rate of spray application; and in Italy on the principal rots of apples and pears.

There is a continuing program headquartered at Fresno, California, involving applied research in entomology and chemistry, directed toward the prevention of insect infestation in dried fruits and tree nuts. The work is conducted in cooperation with California State and County agencies and with several industry groups. In addition to the direct work at Fresno, much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dried fruits and tree nuts.

Federal effort in this program totals 17.8 man-years divided as follows: Objective measurement of quality 2.9; quality maintenance in handling and packaging 1.3; quality maintenance in storage 3.7; quality maintenance during transportation 1.5; postharvest physiology 1.4; postharvest disease control 4.0; and prevention of insect infestation 3.0. Research under P.L. 480 includes a 5-year project in England on the biological effects of modified atmospheres for apples at \$67,031 equivalent; a 3-year project in Italy on apple and pear rots for \$18,357 equivalent; and a 5-year project in Finland part of which involves effects of pesticide residues on deciduous fruits at \$96,411 equivalent.

Projects terminated during this period included: Storage of plums (MQ 2-12); controlled atmosphere storage of western apples (MQ 2-57); and the P.L. 480 projects, X-ray research applied to fruit pathology (E15-AMS-4a) and study of pesticide residues (E8-AMS-1).

CURRENT PROGRAM OF STATE EXPERIMENT STATIONS

Numerous projects at the State stations are concerned with research relating to the market quality of deciduous fruit and tree nuts. Such research includes the development and evaluation of equipment and improved methods for the standardization, sizing, packaging, cooling, storage, and handling of fruits; the selection of optimum handling, transportation, and storage techniques for fruit; investigation of the relation of variety, fertilizer, and harvest and storage methods to the quality of fruit; the development of new methods of packaging, and the evaluation of methods of packaging, handling, and marketing individually packaged fruit; the use of spectrophotometric methods to determine market quality and maturity; and fundamental investigations of the physiological and biochemical processes occurring in harvested fruit.

Postharvest research on apples in the Northeastern region is coordinated through the NEM-27 regional project, Post Harvest Physiology of Pomological Fruits. This project is concerned with the development of objective methods of measuring maturity, ripeness, and condition of fruits for fresh market and processing; with the establishment of principles most conducive to maintenance of high quality fruits during the postharvest period; and with the investigation of physiological and biochemical processes occurring in harvested fruit.

Total market quality research on deciduous fruit and tree nuts at the State stations is approximately 38.8 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Eastern Apples. As in 1964, readings with the Magness-Taylor pressure tester and the mechanical thumb differed from each other significantly in certain varieties and the direction of change was not the same for all

varieties. Correlations of fruit firmness judged objectively by inspectors, as compared with mechanical thumb or Magness-Taylor readings, were significant, but .756 was the highest correlation value, which would be fairly poor for prediction. Correlations between mechanical thumb and Magness-Taylor were also significant, but only one of four varieties (Red Delicious) had a predictable value of .8, the others were less than .7.

Correlations of soluble solids and Magness-Taylor or mechanical thumb readings were generally significant, but again the values were not in the predictable range. The computer data are being analyzed. (MQ 3-28)

2. Western Apples. Starking Maturity: After 3 months in storage a significant correlation was found between lower chlorophyll content in the fruit, as measured with the Difference Meter, and greater flesh firmness. In all examinations the soluble solids were lower in fruit with higher chlorophyll content. Organoleptic evaluations after 6 months in storage on fruit harvested at 145 days indicated a preference for fruit with decreased chlorophyll content. Chlorophyll content of all fruit decreased in storage except that harvested 165 days from bloom. Starkings picked at 145 days from bloom had the best dessert quality at all examinations and the fruit harvested at 135 days was superior to that of 155 or 165 days after 5 months in storage.

Red Delicious Sports: Fruit harvested at 138, 147, and 161 days from full bloom from the three spur type trees--Starkrimson, Redspur and Wellspur--were greener fleshed, softer, lower in soluble solids and poorer in dessert quality after 6 months in storage than the Starking strain which was included as a standard.

Other red strains from standard type Delicious trees were comparable to Starking in these evaluations. Scald was more severe on fruit from the 3 spur type trees than that from the other red strains on standard trees.

Golden Delicious Maturity: Soluble solids of fruit picked from 135 to 165 days from bloom were inversely related to the chlorophyll content. Flesh firmness and acidity were similarly related but not to such a striking extent. Dessert quality was directly related to the soluble solids content. Fruit harvested at 145 and 155 days from bloom had the best keeping quality during 7 months of storage.

B-995 as Related to Maturity and Quality: (1) Golden Delicious apples from check trees and trees sprayed in May with B-995 (dimethylaminosuccinamic acid) were separated according to chlorophyll content on the I.Q. Sorter and comparisons were made on fruit of medium chlorophyll content after 3, 5, and 7 months' storage. Fruit from trees treated with 1000 and 2000 ppm B-995 and harvested at 135 and 145 days from bloom was slightly firmer than the controls. Titratable acidity was consistently higher in all fruit from the B-995 treatments. The taste panel preferred fruit from the treated trees. (2) Starking Delicious apples were 1.0 to 1.5 pounds firmer from trees sprayed following bloom with 2000 ppm B-995 than the check fruit but 1000 ppm had no effect on fruit firmness of the 145-day harvest.

Scald was slightly less on apples from the treated trees but commercial control was not approached. The check fruit from all except the last harvest was generally preferred by the taste panel. (MQ 3-28)

3. Red Tart Cherries. In a study of the relation of oxygen concentration in commercial soak tanks to scald symptoms, scald developed in bruised cherries soaked in tanks with low (less than 2 ppm) oxygen. Very little scald occurred in bruised cherries with 2 ppm or more O_2 in the tank. The maintenance of adequate oxygen in the commercial holding tanks appears to provide effective scald control.

Laboratory experiments with bruised cherries in water or in a nitrogen atmosphere showed that the 2 ppm of oxygen can be considered as the critical level for scald development. In these experiments, no scald was observed in bruised cherries held in water with an almost constant oxygen level of 8.6 ppm by aeration at room temperature ($23^\circ C.$).

The anthocyanin pigments in the skin of ripe, fresh red tart cherries were extracted, partially purified and then separated by paper chromatography with various solvents. A total of seven pigments are indicated. (MQ 3-27)

B. Quality maintenance in handling and packaging

1. Film Permeability for Apple Box Liners. Newly developed formulae permit calculation of effective liner areas for design improvement and adjustment of permeability specifications for apples. Defective liner seams and heat seals were greater sources of leaks than pinholes inherent in the film. A simple, rapid, non-destructive test was developed to detect leaks in either empty or filled liners. Formulae were developed to custom-design liners with minimum dimensions permitting cost savings up to 13 percent. In relating respiratory activity to permeability requirements, the initial respiration of size-113 Delicious, Golden Delicious and Stayman apples in air at 30° to $32^\circ F.$ averaged respectively 3.33, 3.73, and 3.57 mg. $CO_2/kg./hr.$ (MQ 2-63)

2. Lenticel Spotting of Golden Delicious Apples. A few lenticel spots developed on Golden Delicious apples exposed to formaldehyde fumes at 250 and 500 ppm, but skin of the fruit discolored in all of the treatments before significant incidence of lenticel spotting. In the previous two years' work with packaging materials having a faint odor of formaldehyde as a result of materials used in formulation, serious spotting occurred without skin discoloration. (MQ 2-72)

3. Blueberries. Wolcott blueberry fruits from 3 harvest dates at each of 2 locations were separated into 8 stages of ripeness based on visual coloration. During ripening the total acidity decreased from 4.0 to 0.5 percent, soluble solids increased from 6.9 to 13.4 percent and anthocyanins increased from 0 to 3 mg per square centimeter of fruit surface. Regardless of location or harvest date, there was a high degree of consistency in sugars, acids, and anthocyanin content for each stage of ripeness and a significant correlation between the

amount of anthocyanin and the ratio of soluble solids to acid which is accepted as a reliable measure of ripeness. Studies are now underway to determine the usefulness of light transmittance for determining anthocyanin content of the berries.

In a large commercial cold storage equipped to employ forced air cooling of the packed blueberries, tests showed half-cooling times of approximately 1 hour, which is in agreement with previous experimental data. (MQ 2-94)

C. Quality maintenance in storage

1. Controlled Atmosphere Effects on Stayman Apples. Stayman apples stored in each of 16 different controlled atmospheres (CA) for 6 months at 32° F. responded much like Red Delicious under similar CA conditions. Fruit from the 1% oxygen atmospheres had fewer external and internal disorders than fruit from atmospheres with either higher (3 or 21%) or lower (near zero) oxygen levels. Firmness and acidity were highest in fruit from the lowest oxygen atmospheres and generally decreased as the oxygen concentration increased. Carbon dioxide production after storage was found to be lowest in fruit from the lowest oxygen levels and increased with increasing oxygen concentrations in the storage atmosphere. A fermented flavor developed in fruit from the lowest oxygen atmospheres. (MQ 2-63)

2. Controlled Atmosphere Storage of Eastern Peaches and Nectarines. Freshly harvested Redhaven and Sunhigh peaches were stored at 32° and 40° F. for 3 weeks in controlled atmospheres (CA) of 1/2, 1, 3, and 21 percent oxygen in combination with zero or 5 percent carbon dioxide and the balance of each atmosphere nitrogen. All of the fruit stored at 32° ripened satisfactorily in air at 60° and there were no appreciable differences in firmness or appearance between peaches in any of the test atmospheres. Peaches from the 1/4 percent oxygen with zero or 5 percent carbon dioxide and those from the 1 percent oxygen with 5 percent carbon dioxide atmospheres ripened in 6 days at 60°, while peaches from the other atmospheres ripened in 4 to 5 days. None of the fruit stored at 40° for 3 weeks in the various atmospheres ripened satisfactorily when transferred to air at 60°. Respiration of peaches in air at 60° was lower for those previously in CA than those in air continuously and also slightly lower in the lots previously stored with 5 percent carbon dioxide than those with 0 percent carbon dioxide. Results with Late Le Grand nectarines were similar to those with peaches. Differences between treatments were slight. A taste panel preferred fruit from storage atmospheres with CO₂ present. (MQ 2-99)

3. Controlled Atmosphere Storage of Western Peaches. Redhaven peaches were held at 31° F. in controlled atmospheres with oxygen at 0.5, 1.0, 2.5, and 5.0 percent, balance nitrogen; carbon dioxide at 2.5, 5.0, and 10.0 percent in air; combinations of 1.0 percent oxygen with the 3 carbon dioxide levels; and air. After 4 weeks, all CA fruit was superior to that in air, which had become dry and mealy. After 6 weeks, the peaches in 1 percent oxygen plus 2.5 and 5.0 percent carbon dioxide were still edible but quality was poor. All other lots were unacceptable. (MQ 2-99)

D. Quality maintenance during transportation

1. Air Shipment of California Strawberries. Precooled strawberries shipped from California to east coast markets by air in June had temperatures of 40° to 54° F. at destination. A partially sealed polyethylene pallet cover and dry ice resulted in a 10% concentration of CO₂ at destination. With the conventional fiberboard sleeve and cap over the pallet, the CO₂ was only 1.7% at destination. After holding there was slightly less decay in the fruit shipped in the polyethylene covered pallet than in that with only a fiberboard cover. Using dry ice without a polyethylene cover appears to be of questionable value. (MQ 2-83)
2. Thermal Conductivity of Apple Tissue. The mean thermal conductivity value for the flesh of Georgia-grown Delicious apples was 2.32 BTU/hr/ft²/°F/in. with a mean moisture content of 84.8 percent. A direct correlation was found between the moisture content and the "k" values. (MQ 2-53)

E. Postharvest physiology

1. Scald Control for Apples and Pears. Dipping eastern-grown Stayman apples for 10 seconds in 2000 ppm diphenylamine (DPA) or 2700 ppm ethoxyquin (Stop Scald) before storage provided excellent scald protection during 5 to 6 months' storage in 4 tests at Beltsville. A 30- or 60-second dip in 130° F. water on either warm (65-70°) or cold (40-45°) Stayman apples also provided very good scald control. A 60-second dip in 120° water was much less effective. Post-harvest dips of 10 seconds in 1% dimethylsulfoxide (DMSO) and 2000 ppm dimethylaminosuccinamic acid (Alar) alone or in combination gave no scald control and the DMSO tainted the fruit. None of these treatments affected fruit firmness or appreciably altered respiration. Ten-second Alar dips at 2000 and 4000 ppm reduced ethylene production at 32° in McIntosh, Rome, Stayman and Arkansas varieties but not in Golden Delicious.

DPA dips and wraps and a combination of dips and wraps controlled scald on western-grown Starking apples through April but by June scald control was poor in all treatments. Neither ethoxyquin (Stop Scald) nor diphenylamine, dissolved in commercial apple wax preparations at concentrations of 1000, 2000, and 3000 ppm and applied with a commercial waxer to Starking apples controlled storage scald. Wax alone caused an increase of scald. Wax containing DPA greatly reduced scald on Golden Delicious apples. Ethoxyquin dissolved in commercial wax preparations reduced scald development and skin discoloration from abrasions on Anjou pears. Wax without ethoxyquin did not reduce scald or discoloration. Waxed pears ripened more slowly than unwaxed pears, but they ripened to good quality and had good shelf life. DPA residues in fruit with wax plus DPA were less than 0.5 ppm at 2 months and decreased thereafter. Residues of dip treatments decreased with time, while those on fruit in wraps increased between 2 and 4 months and decreased thereafter. All treatments were well below the DPA residue tolerance. (MQ 2-91)

2. Apple Respiration at Modified Atmospheres. This P.L. 480 study at Ditton Laboratory in England has now been completed. Much basic information has been obtained on the respiratory activity of apples stored in different atmospheres at temperatures from 32° to 54° F. The data indicate increased toxicity of carbon dioxide as oxygen is reduced at low storage temperatures. At 5% oxygen or above respiration was not limited at 32° but at 38° and 45° reduced oxygen concentration limited respiration activity, as compared with air, even at 10 and 15% concentrations. Results with the addition of .05% ethylene to the storage atmosphere confirmed previous findings that it is without effect on respiratory activity at 32° or 38°. Some earlier discrepancies in RQ (proportion of CO₂ evolved to O₂ used) seem now to be explained by different peak periods for CO₂ output and O₂ uptake during storage. (E29-AMS-1a)

3. Anjou Pear Scald. This research conducted by the Oregon Agricultural Experiment Station under contract has been completed and a final report submitted. Tests with artificially cooled and heated bearing limbs showed that within the temperatures used susceptibility to scald was not influenced by temperatures during the 2- to 4-week period before harvest. Physiological changes associated with scald development appear to be initiated early in the storage period and were not associated with wax content, volatiles in the cuticle, or changes in specific polyphenols in the epidermal layer. Excellent commercial control of scald was obtained with ethoxyquin either as a prestorage dip at 2700 ppm or incorporated in the widely used copper oil wrap at 2-10 mg per wrap. (MQ 2-66)

4. Effects of Pesticides on Storage Quality. This new P.L. 480 project in Finland is just getting underway. Investigations include the effects of CIPC, IPC and other postharvest fungicides on composition and storage life of tree fruits and berries. (E8-AMS-6a)

F. Postharvest disease control

1. Forecasting Storage Diseases of Apples. Loose fruit of 6 grower lots of Delicious and Winesap apples was washed in a fungicide (sodium-o-phenylphenate) and held at 70° F. in film liners. Packed fruit from the same lots were held in a commercial cold storage room. Apples in the warm room were examined for decay at weekly intervals from 2 through 5 weeks and the fruit in cold storage was examined at monthly intervals from 4 through 7 months. After 3, 4, and 5 weeks in the warm room decay ranged from 3 to 5, 2 to 15, and 4 to 17 percent, respectively. In the cold room there was no decay after 4 and 5 months, but after 6 and 7 months decay ranged from 0 to 2 and 1 to 3 percent, respectively; and a general relationship with the extent of decay at the higher temperature. (MQ 2-67)

2. California Grapes. Hydrocooling reduces the temperature of Emperor grapes very rapidly, improves the appearance of the fruit, and reduces weight loss and desiccation of the stems. Hydrocooled grapes had no more decay after 3 months' storage than grapes that were not hydrocooled, when both were similarly fumigated with SO₂. However, the 1964 season was relatively dry before harvest and tests must be repeated in a wet year.

Fumigation of Emperor grapes as much as 14 hours after inoculation with 1000 to 8000 ppm SO_2 controlled most incipient Botrytis infections at 72° F. As the incubation time before fumigation was increased beyond 14 hours, the infections became increasingly resistant to SO_2 . In this experiment, the concentration of SO_2 had little effect. (MQ 2-101)

3. Heat Treatment for Blueberries. Twelve lots of Maryland or New Jersey blueberries were treated for 2 minutes in 125° F. water for 30 minutes in 110° air with 99-100 percent relative humidity. After 2 days at 40° plus 4 days at 70°, postharvest spoilage was reduced from an average 48 percent in dry control lots to 15 percent in hot-water treated lots. Hydrocooling following heat treatment was beneficial when clean water was used but dirty water recontaminated the berries and increased decay. (MQ 2-104)

4. Decay Control for Strawberries. California strawberries heated in a water-saturated atmosphere for 40 to 60 minutes at 111° F. had about 3% decay after 5 days at 37° plus 2 days at 60° F. Untreated lots had about 10% decay. Slight injury occurred in a few replicates heated for 60 minutes, but no injury was found in the 40-minute treatment. A taste panel could detect no differences in flavors or texture between heated and non-heated berries. Gray mold rot of strawberries was effectively reduced in berries held in atmospheres with 0, 1/4, or 1/2% oxygen for 5 days at 37° plus 2 days at 60° F. but 1% oxygen was not effective. Off-flavors in all 4 varieties were always detected in berries held at 0% and 1/4% oxygen. (MQ 2-83)

5. Heat Treatment for Cranberries. A 10-minute dip in 115° water before storage for 3 or 4 months at 38° F. reduced spoilage of cranberries by about 40% from each harvest of 3 Massachusetts bogs. A dip of 2½ minutes in 125° water reduced decay of early-harvested berries and caused little or no injury. Late-harvested berries were injured by this treatment. Late-harvested berries usually had more spoilage than early-harvested berries. (MQ 2-104)

6. Heat Treatment for Peaches. Seven tests were conducted in Fort Valley, Georgia during the 1965 season when incipient infections (pin point rot) prevented the shipment of many peaches. Decay (brown rot) of these peaches during 2 days' holding at shed temperatures was reduced by 84 percent by treating peaches in 127° F. water for 2½ minutes. Peaches heated in 130° water for 3 minutes were no more susceptible to infection by Monilinia (brown rot) spores than unheated peaches. Heated peaches were slightly more susceptible to infection by Rhizopus (soft rot) spores. Peaches hydrocooled in clear water containing brown rot or soft rot spores and held at 70° F. for 6 days developed about 75 percent more brown rot and 65 percent more soft rot than those hydrocooled in clean water. Addition of 100 ppm of chlorine, as sodium hypochlorite, to the contaminated water reduced both decays by about 60 percent. The amount of free chlorine available from added sodium hypochlorite was found to be related to the amount of organic matter in the water. Organic matter at 0.6 percent reduced available chlorine by about 50 percent after 4 hours. Organic matter at 5.0 percent reduced available chlorine by about 75 percent within a 1/2 hour. (MQ 2-104)

7. Heat Treatment for Figs. Three varieties of fresh figs were heated in water-saturated air at temperatures of 111°, 115°, 118°, 126° and 133° F. for 1 hour. After 5 days at 37°, then 2 or 3 days at 60° surface mold and decay affected 30 to 60% of the untreated figs, but usually affected less than 5% of figs heat-treated at 115° or above. Some inhibition of ripening also occurred at these temperatures, ranging from barely noticeable at 115° and 118° to an objectionable effect at 126° and 133°. (Exploratory)

8. Heat Treatment for Chestnuts. Louisiana chestnuts containing about 51 percent incipient fungus infections were treated with hot water and stored 2 months in perforated polyethylene bags at 40° F. All of the hot water dips greatly reduced decay during storage as compared with the wet and dry checks. Best decay control, without injury, was 1 hour in 125° water. Soaking nuts 15 minutes or longer in water at 140° or higher caused severe injury. (MQ 2-104)

9. Ozone Treatment of Strawberries. Ozone did not reduce rot or extend the market life of strawberries held in high relative humidity at 55-60° F. and ozone at 0.05 to 10 ppm. Shriveling and drying of the cap occurred at concentrations of 0.5 ppm and higher. (MQ 2-102)

10. Effects of Atmosphere Modification on Growth of Certain Fungi. Growth of decay-causing organisms was studied in atmospheres typical of controlled atmosphere storages or nitrogen refrigerated trailers. At a temperature of 15° C., Botrytis cinerea, Cladosporium herbarum, Alternaria sp., and Rhizopus stolonifer grew significantly slower in atmospheres with less than 1% oxygen than in air and were completely inhibited in the absence of oxygen (100% nitrogen). The addition of 15% carbon dioxide to an atmosphere containing 0.5% oxygen reduced the growth rate of these fungi below that at 0.5% oxygen alone. (MQ 2-112)

11. Postharvest Disease Identification. Morphological and physiological studies of a species of Phytophthora isolated from Indiana peaches have shown that the organism is the "parasitica" species.

Morphological, physiological and pathological studies of a disease of California strawberries (not previously reported in the literature) have shown the causal organism to be Phytophthora cactorum. (MQ 2-64)

12. Radiation on Pathogenicity of Fungi. The frequency of both spontaneous and radiation induced sodium orthophenylphenate (SOPP) and sodium dehydroacetate (DHA-S) resistant mutants of Penicillium expansum was studied. In two color auxotrophic mutants, spontaneous resistance was obtained with a frequency of 2 to 3 per 10 million spores. In the normal wild-type, the frequency of SOPP resistance was 35 per 10 million spores. Following radiation which resulted in 97 to 99% kill of conidia, the frequency of both SOPP and DHA-S mutants increased substantially in both mutant and wild-type isolants. Most of the SOPP and DHA-S resistant mutants were avirulent in Jonathan apples. In vitro tests showed all mutants to produce copious amounts of pectolytic enzymes. Avirulence may be associated with permeability changes

to mutant spores. Avirulent mutants of P. italicum and P. digitatum grown with pectin as the carbon source gave filtrates with pectolytic activity. Orange tissue rotted by P. italicum or P. digitatum had both pectolytic and cellulolytic activity; necrotic tissue produced by avirulent mutants of these species had cellulolytic but not pectolytic activity. The pectolytic and cellulolytic enzymes of P. italicum and P. digitatum could be distinguished by their activity curves at different pH values and rates of thermal inactivation. (MQ 2-96)

13. Pesticide Residues. This P.L. 480 project in Finland has been completed and terminated. Nine manuscripts have been prepared on different phases, 3 of which relate to postharvest fungicides. The studies have clearly shown what residues will result from postharvest use of Captan, CIPC, or IPC; what part is removed by simple washing; what part persists through storage or processing; and what degradation products occur. These are helpful data to research people working with the chemicals and to public health agencies concerned with chemical residues. (E8-AMS-1a)

14. Apple and Pear Rots. This P.L. 480 project in Italy is developing much information with useful illustrations, on the rate and nature of growth of Botrytis sp. and Penicillium sp. in apples and pears. Such factors as maturity at harvest, delays before storage and storage temperature are being related to decay development. Further studies are underway on the effect of orchard fertilizers and fungicidal sprays on postharvest decays and work has been started on postharvest treatments for decay reduction. (E15-AMS-2)

15. Proteolytic Enzymes in Relation to Market Quality. Extracts assayed for proteolytic activity were derived from one or more apple, pear, onion, and bean varieties infected with one or more isolates or species of six fungi. The results suggest that proteolytic enzyme activity is not important in decays caused by Botrytis, Monilinia, Neofabraea, or Penicillium. Extracts from apples inoculated with Botryosphaeria and Alternaria produced proteolytic enzyme activity whereas an extract from Anjou pear inoculated with Botryosphaeria was negative.

Extracts from oranges and lemons inoculated with one or more isolates of Alternaria citri, Diplodia natalensis, Penicillium digitatum, P. ultimum, or Phomopsis citri were prepared to permit confirmation and extension of preliminary assays with citrus. (MQ 2-97)

G. Prevention of insect infestation

1. Improved Pesticidal Control Methods. Malathion dusts were more effective than emulsions when applied at varied dosage rates on raisins or walnuts and almonds in the shell. These were preliminary laboratory evaluations of malathion as a protective treatment, using eggs, larvae, and adults of the Indian-meal moth and the merchant beetle. The treatments were most effective in preventing infestations resulting from introduction of eggs. Larvae were the most resistant stage. Adults of a dermestid beetle, Trogoderma inclusum, were exposed to treated almonds and walnuts and were much more difficult to control than the other two species. (MQ 1-15)

Aerosol applications of dichlorovos in fruit processing plant areas gave good initial kill of Drosophila but no lasting control. Dichlorovos vapor dispensed from a specially designed generator gave excellent initial kill, some mortality into the second day, and reduced populations for 3 or 4 days after the initial application.

Residues were higher in raisins dried on malathion-treated trays during the excellent drying season of 1964 than they were from the rainy drying season of 1963. The previously observed differences in residues in relation to the type of roll used and whether or not the raisins were turned during drying did not show up in 1964. There was, however, a significant difference of 5 ppm between residues in raisins dried on 2 different ranches. (MQ 1-34)

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Objective Measurement of Quality

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AREA 4

GRAIN-MARKET QUALITY

Problem. Grain and cereal products are subject to damage or deterioration in quality while in the marketing channels through normal metabolic changes, by the action of microorganisms, and by the attack of more than 50 species of stored-product insects. This deterioration affects the grade and price received, the end use, and the wholesomeness of the product. Its effect may be conspicuously blatant, or insidiously hidden; may result in the destruction of nutrient values, or insects may render it esthetically unacceptable. Research is needed not only to protect this multibillion dollar crop from evident deterioration but from the hidden damage as well. Surplus crops and longer storage periods make once accepted standard procedures obsolete. New methods of protection from insects and disease, of identifying and measuring quality changes, and means of maintaining quality over longer periods of time are some of the problems requiring attention.

USDA PROGRAM

The Department has a continuing program involving chemists, engineers, and plant pathologists in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods for quality evaluation of cereal grains. The research is conducted at Beltsville, Maryland, and also by cooperative agreement with Purdue University, Lafayette, Indiana, and by research contract with the University of Arkansas, Fayetteville, Arkansas. The program includes the following foreign projects under PL 480: a grant to the Israel Institute of Technology, Haifa, Israel, provides for a study to develop tests for nutritive value of cereal grains and feeds. Its duration is 4 years, 1960-1964, and involves PL 480 funds equivalent to \$103,785 in Israeli pounds.

A grant to the Agricultural Higher School, Poznam, Poland, provides for a study of the effect of microflora of wheat flour on its stability, biochemical, and technological properties. Its duration is 4 years, 1961-1965, and involves \$13,091 equivalent in Polish zlotys.

The Federal scientific effort devoted to research in this program totals 6 professionals divided as follows: quality maintenance and evaluation 5; and contract research 1.0.

There is also a continuing program involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination of grains and cereal products in the marketing channels.

The activities in Manhattan, Kansas, and Tifton, Georgia, are in cooperation with the respective State Agricultural Experiment Stations. The work at Manhattan, Tifton, Savannah, and Watseka, Illinois, is in cooperation with the Agricultural Stabilization and Conservation Service. During the first half of the fiscal year the equivalent of 0.7 professional man-year of effort distributed between Manhattan, Savannah, and Watseka was supported by CCC funds. At the end of December 1964 the experimental binsite at Watseka was closed down after having been supported for several years by CCC funds. The entomologist was transferred to Manhattan and assigned to research supported by regular funds. The CCC also makes available various commodities and storage facilities for experimental use, thus greatly facilitating the program. There is cooperation with the Field Crops and Animal Products Research Branch of this Division in studies relating to quality maintenance during storage, and on quality evaluation of grains and cereal products; and with engineers of the Transportation and Facilities Research Division on matters relating to storage structures and grain aeration. There is cooperation with growers' cooperatives at Manhattan and with various industry groups at all locations. There is also overall cooperation with several State Experiment Stations through participation in Regional Project WM-52, Maintaining Marketability of Stored Grain and Cereal Products Through Insect Control by Methods Leaving No, Or a Minimum Of, Pesticide Residues.

The program was supplemented by eight PL 480 projects as follows:

A grant to the Direzione Generale dell' Alimentazione, Ministry of Agriculture and Forests, Rome, Italy, is for a study of insect infestation in macaroni, noodles, and spaghetti, and of ways to prevent such infestation. It became effective in 1962, continues through December 1965, and involves P.L. 480 funds with a \$42,621.90 equivalent in Italian liras.

A grant to the Administration of Agricultural Reserves and Surpluses, Montevideo, Uruguay, is for the study of underground and aboveground storage of corn in airtight silos in relation to maintaining quality and preventing insect infestation during long term storage. It became effective in 1962, continues to May 1967, and involves P.L. 480 funds with a \$73,041.93 equivalent in Uruguayan pesos.

A grant to the Indian Agricultural Research Institute in New Delhi is for a study of the varietal resistance of wheat kernels to damage by the rice weevil and lesser grain borer. It became effective in 1965, continues to February 1968, and involves P.L. 480 funds with a \$15,146 equivalent in Indian rupees.

A grant to the Hebrew University at Jerusalem, Israel, was originally for basic research on the influence of environmental conditions on the population dynamics of the khapra beetle. It was extended two years for further biological investigations. The project became effective in 1961, was extended

through October 1966, and involves P.L. 480 funds with a \$97,123 equivalent in Israeli pounds.

A grant to The Maharaja Sayajirao University of Baroda, India, is for basic research on the physiology of fat metabolism in relation to diapause in the khapra beetle. It became effective in 1965, continues through January 1970, and involves P.L. 480 funds with a \$33,907 equivalent in Indian rupees.

A grant to the Instituto Superiore di Sanita in Rome, Italy, was to study the fate of insecticide residues in wheat during storage, milling, and baking or processing into wheat products. The project was terminated prematurely but excellent information was obtained during its short duration.

A grant to the University of Helsinki, Finland, is to study the effects of pesticides on plant commodities. Part of the study will be on wheat. The project became effective in 1964, will continue through December 1969, and involves P.L. 480 funds with a \$96,441 equivalent in new Finnish finnmaks.

A grant to the Hebrew University in Rehovot, Israel, is to study the effect of ethylene dibromide on farm animals. It became effective in 1961, has been extended to August 1966, and involves funds with a \$177,441.99 equivalent in Israeli pounds.

The Federal scientific effort devoted to research on prevention of insect infestation totals 8.2 professional man-years. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in grain and grain products.

Line Project MQ 0-0-1 (CCC) was discontinued in December 1964 when CCC financial support was withdrawn. Some phases of the project are continuing under regular funds.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations are engaged in both basic and applied research on the market quality of grains. A discussion of the program on insect control is included under Area 13.

Considerable effort is devoted to the varietal and quality improvement of grains. For example, when barley is grown for malting purposes, the malting factors are evaluated to determine what effects various varieties, cultural practices and environments have on malting quality. Twelve States are researching the various phases of quality of cereals. The four Federal regional wheat laboratories are located in four of these States. Both State and Federal researchers cooperate closely on this program. Research on the

quality of soft red winter wheat is coordinated through the NCM-28 regional project, with the Federal laboratory at Wooster, Ohio participating in this regional project along with the Ohio, Indiana and Missouri stations. Basic studies involve the improvement of testing methods, the chemistry of bleaching action on starch, lipid and protein interactions in cake baking tests, and the identification of proteins and amino acids associated with good baking quality. Fractionation of flour, particle size, as well as density and air classification, is being studied with wheat flour.

The quality characteristics of experimental strains of wheat are evaluated as well as changes in quality of wheat associated with time and conditions of storage. The various chemical and physical measures are applied in evaluation of quality factors.

There are about 5.7 professional man-years devoted to research on the market quality of grains.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Quality Indicators for Stored Wheat. Selkirk, a hard red spring wheat, and Triumph, a hard red winter wheat, harvested in 1963 were placed in storage at 86° and 50° F. and 12, 14, and 16 percent moisture content. The results show that the wheats stored at 86° F. changed at a faster rate than at 50° F. Also, some of the changes were less pronounced for Triumph than for Selkirk. Fat acidity values generally increased faster and losses in sedimentation values were greatest in the spring variety. This suggests that wheats of different classes do not react alike under the same conditions of storage.

The capacitance-resistance determination, a relatively quick, simple test, and the glutamic acid decarboxylase activity determination (methods for measuring deterioration in wheat) proved to be relatively satisfactory measures for following the changes (losses) in stored wheats. Physical dough tests (mixograph and farinograph) indicated that the mixing tolerance properties, an important consideration to the commercial baker, were improved by storage even for the grain stored at 50° F.

According to the baking tests, there is an indication that Triumph is perhaps stronger, changing less (decreasing) in loaf volume than Selkirk under these conditions of storage. Samples of the highest moisture content (16%) evidenced generally the greatest decline during storage in overall quality, with the 14% moisture samples less and the 12% moisture samples the least.

2. Sampling Research. A cooperative agreement was signed with Cargill, Inc. for use of elevator facilities, and the necessary installations made for evaluating mechanical grain sampling devices. These are now in progress.
(MQ 3-24)

3. Test Weight-Flour Yield. Methods of measuring bran content, or bran and germ content, and endosperm content as indicators of the flour-yielding capacity of wheat are being investigated. Three methods for measuring bran content are dye absorption, pigment measurement, and lactic acid digestion. In each of the three methods, the germ content of the wheat kernel is also believed to influence the measurement so that it is actually a measure of the bran and germ content. The lactic acid digestion, which leaves a branny residue, appears to be the most sensitive of the three methods in relation to flour yield. Collection and analysis of data on these three methods is not yet complete.

A small mill, the Brabender Quadramat, is being tested as a possible mechanical indicator of the flour yield from the larger Buhler experimental mill. Preliminary results indicate correlations for Quadramat vs. Buhler yields are better for hard wheats than for soft wheats.

Like last year, differences in milling characteristics among the classes of wheat continue to show up in practically all methods of measuring flour yields.
(MQ 3-36)

4. Protein Content of Sorghum and Other Feed Grains. A colorimetric-sulfo-salicylic acid test used for measuring protein content of wheat was modified by doubling the sample weight as well as reagent. A significant correlation was obtained between meter readings and Kjeldahl protein on 44 samples of milo.
(MQ 3-58)

5. Kernel Hardness of Wheat. This project was recently approved and no report has been received from the investigator.
(E19-MQ-1(a))

6. Macaroni and Spaghetti Products. The most satisfactory results have been obtained with two color reaction modifications of the Matweef procedure but the tests showing the most promise are time consuming. Optical density measurements of the sitosteryl palmitate fraction also detect in a relatively satisfactory manner, the presence of the different proportions of common wheat used in flour mixtures and finished macaroni products.
(E25-AMS-7(a))

7. Mixed Corn of High and Low Moisture Contents. Eight series of moisture determinations on individual kernels, each involving 140 kernels taken from the same sample, have been made. The results indicate the variation in moisture content of individual kernels found in the unmixed samples.
(Exploratory)

8. Aflatoxin in Corn. Culture extracts produced by 107 fungi isolated from corn grains were assayed by thin layer chromatography for aflatoxin. Certain isolates of Aspergillus awamori, A. flavus, A. parasiticus, A. ruber, A. wentii, Penicillium citrinum, and P. variable produced aflatoxin. Penicillium cyclopium, P. frequentans, and P. puberulum elaborated this toxin only in trace amounts. Bioassays of extracts from 4 of these fungi showed that only the extract from A. parasiticus was highly toxic.

(Exploratory)

9. Baking Quality of Wheat. A satisfactory baking quality test is a continuing need for the quality evaluation of wheat. A simple flour-disc test is promising for determining bread baking quality in wheat. The flour-discs were made by pressing a mixture of ground whole wheat and lactic acid in a Carver press. Agtron reflectance readings of the flour-discs gave highly significant correlations with protein, sedimentation, and loaf volume values. Moisture meter correction factors were established for measuring moisture content in various types of wheat treated with diatomaceous earth for hard red spring, hard red winter, soft red winter, and white wheat.

(MQ 3-3)

B. Quality maintenance in storage

1. Changes in Wheat Due to Insecticides. After storage for one year, wheats treated with Cab-o-sil, Silica Aerogel 68, Perma Guard, and Kenite, showed no further decrease in test weight per bushel and no change in the yield of flour, as compared with the untreated wheat. The malathion-treated wheat was not changed in test weight or yield of flour after storage. The different dust or liquid insecticide materials appear to have no effect on the fat content of the treated and stored samples as compared with the control wheat. Normal cleaning of the grain in preparation for milling removed a large percentage of the dust insecticide materials judged by visual inspection. There were no important differences in chemical quality tests, in physical dough tests, or bread baking characteristics of the wheats between initial treatment and after 1 year of storage compared to the control sample.

(MQ 2-70)

2. Changes in Wheat Due to Radiation. Samples of hard red winter wheat treated with 0, 10, 25, 50, 125, and 175 thousand rads of gamma radiation have been stored one year at 75° F. Initial germination values were unchanged by 10 and 25 thousand rad treatments, materially decreased by 50 thousand rads and destroyed by the 125 and 175 rads treatments. The losses in germination were less for the 10 thousand rad treated wheat than the other treated samples after 1 year of storage. There were significant initial losses in sedimentation values with increasing levels of radiation, but no additional losses in sedimentation after 1 year of storage. Irradiation treatment had no effect on initial fat acidity but storage for 1 year increased the values somewhat. Enzyme activities, as indicated by the glutamic acid decarboxylase values were unchanged by increasing initial dosages of irradiation but showed marked decreases with time of storage. The capacitance resistance determination

a rapid test for deterioration in corn, showed no changes in the wheats when initially treated but increased gradually during the 1 year storage period. The treatments tended to slow down desirable physical changes in dough properties, but had no effect on loaf volume. Dosages of 125 and 175 thousand rads produced distinct off odors (burned, charred, or decayed) in the hot breads but these were not evident in the cold loaves. A trained judging panel found no significant difference in the taste of the breads from the irradiated and non-irradiated wheat.

(MQ 2-70)

3. Microflora of Wheat. Conditioned wheat (cleaned, washed, and heat treated) produced a higher yield of flour than either the cleaned or washed grain. The flour from the conditioned wheat spoiled more rapidly on prolonged storage than the flour from untreated washed grain. Fat acidity values of the flour were highest in the untreated and washed grain and lowest in the conditioned wheat. Flour stored at 20° C. and 90% relative humidity decreased in fat acidity after 8 months' storage, suggesting complete spoilage of the flour and destruction of the fats and free fatty acids due apparently to molds. The bread-baking characteristics in terms of loaf volume, have generally improved, for the flours stored under various conditions except for storage at the highest temperature (20° C) and relative humidity (90%). Organoleptic evaluations, surprisingly, showed development of off odors and flavors in the bread from flour stored 10 to 12 months at the low temperature of 3° C.

(E21-AMS-7(k))

4. Long-Term Storage of Wheat. Nine samples of Marquis, a spring wheat grown under irrigation from 1921 to 1929, and four samples of Kanred, a winter wheat grown without irrigation during a like period of years, were stored 35 to 43 years at Fort Collins, Colorado, in bags in a dry unheated room. The germination of the wheats decreased progressively with age but Kanred lost viability somewhat faster than Marquis harvested in the same years. There was no change in protein content during storage but the ash content of the flour averaged consistently higher than when the original tests were made (1938). Thiamine content was generally comparable to that of freshly harvested wheat of the same varieties. There was a definite and fairly uniform increase in fat acidity during storage. Sedimentation values determined for the first time in 1964 were low compared to recently harvested wheat of like variety. Dough mixing properties (by the farinograph) for the 35 to 43 year old wheat were remarkably strong with Marquis somewhat superior to Kanred. The quality of the bread decreased somewhat with greatest losses in bread grain and texture.

Tests of these stored wheats have been made periodically. This recent study is being prepared for publication and will constitute the fifth paper in the series on this subject.

(MQ 2-70)

C. Prevention of insect infestation

1. Nonpesticidal Control Methods. Small-bin studies with varied dosages of inert dusts showed that 2 diatomaceous earths were highly superior to 2 silica aerogels over a period of 15 months. The diatomaceous earths were also superior to the standard dosage of malathion. (MQ 1-27 (Rev.))

In a field test on corn in Illinois, malathion, 2 diatomaceous earths, and 2 silica aerogels all continue to give a high degree of protection against insect infestation 21 months after treatment. At the end of 21 months of a field test with corn in Georgia, a diatomaceous earth and a silica aerogel continue to be comparable with malathion in protecting against insect infestation. In laboratory bioassay tests of corn from the field test, the inert dusts gradually decreased in toxicity and repellency as the length of storage increased. In these field tests the flow rate of grain through grain handling equipment was greatly reduced in the dust treatments and test weight was lowered several pounds per bushel. It was also exceedingly difficult to insert probes into the dust-treated grain for inspection and sampling. None of these difficulties resulted from the malathion treatment. (MQ 0-0-1(CCC))

Seventy-one test crosses of corn from the Crops Research Division were tested for repellency to the rice weevil, using a common hybrid, Coker 71, as the reference check. Thirty-three of the test crosses showed repellency, six rating above 55 percent. (Exploratory)

Some rice weevil, granary weevil, and lesser grain borer adults and eggs were able to survive exposure in laboratory tests to extremes of vacuum, pressure, or temperature exceeding those used in pasta manufacturing processes. Other investigations still indicate that insect infestation of pasta occurs after manufacture. Examination of almost 18,000 weevil galleries in "camolata" pasta from all over Italy showed that the eggs had been deposited in the pasta not only after it had been ejected from the dies but also after final processing. (E15-AMS-9(a))

Corn was sampled from aboveground hermetic silos after storage for one year in tests in Uruguay. The corn was in good condition and no insects were present. Air samples from within the bins contained 27 to 46 percent of carbon dioxide and only 0.18 to 0.5 percent of oxygen. (S9-AMS-6(a))

2. Biology, Ecology, and Physiology. A seasonal cyclic variation in composition of air in 3,250-bushel metal bins of wheat was found in Kansas. There is a minor build-up of CO₂, reaching a peak of 0.16 percent in October. As the grain cools, the concentration decreases slowly, becoming lowest in April. As the grain warms the CO₂ again increases to a peak in October. (MQ 1-18)

Preconditioning adult flour beetles with CO₂ or N₂ to increase susceptibility to fumigation was more effective at 30° C. than at 20° or 40° C. Confused flour beetles secreted large amounts of paraquinones during recovery from CO₂ or N₂ preconditioning, and these compounds accumulated in toxic amounts if not removed by active ventilation. Insects were most susceptible to low concentrations of methyl bromide fumigant while in a condition of depressed rather than high respiration rate. It is assumed the detoxification of methyl bromide by the insect was slower at low metabolic levels. Preconditioning did not affect the insect's susceptibility to chloroform as a fumigant when exposure was at either a high or low rate of respiration. (MQ 1-31)

Rice weevils appear to prefer clean wheat to that with high concentrations of dockage. But when immature stages were left in the wheat to continue their development more progeny were found in wheat with greater amounts of dockage. (MQ 0-0-1(CCC))

When 1 to 4 pairs of adult khapra beetles were placed in 3.5 grams of wheat, the greatest number of larvae was produced by the 4 pairs but the greatest number of pupae resulted from the single pair. The higher the population density the greater was larval mortality and the longer was the larval developmental period for females. Wheat kernels from a khapra beetle culture appear to contain substances that cause mortality and delayed development of larvae reared on that food. Rinsing partly eaten grain in water or ether appeared to remove the adverse factor, but when insects were reared on the ether-rinsed grain an unexpectedly high proportion, 77 percent, of the resulting beetles were females. It appears that a petrol-ether solvent, but not water, removes from khapra beetle excreta a factor that inhibits pupation and induces diapause in larvae. Khapra beetle larvae were strongly attracted to an extract of larvae of the same species in olfactometer tests, and there are indications the attractant is rather volatile. Khapra beetle larvae were not attracted by extracts of four other species of larvae. (A10-AMS-11(k))

3. Improved Pesticidal Control. Applications of 5 p.p.m. of diazinon or fenthion to grain, then aged for one year, were equal or superior to malathion at 10 p.p.m. against test insects in the laboratory. Diazinon or fenthion at 10 and 20 p.p.m. and aged one year were completely effective against all species of test insects. Carbaryl was found to have definite specificity for control of the lesser grain borer. (MQ 1-15)

In tests of fumigants for use behind the linings of empty rail cars, a mixture containing 70 percent of ethylene dibromide and 30 percent of methyl bromide was better than one containing 80 percent of carbon tetrachloride and 20 percent of carbon disulfide. Laboratory tests with phosphine show a higher concentration-x-time factor is required against flat grain beetles than other common stored-grain insects. (Exploratory)

In studies of physical behavior and distribution of liquid grain fumigants in corn, cold weather adversely affected the mixture containing 75 percent of ethylene dichloride (EDC) and 25 percent of carbon tetrachloride (CCl_4). Volatilization of the EDC was delayed and distribution was limited to the upper half of the bin. Distribution of a mixture containing 80 percent of CCl_4 and 20 percent of carbon disulfide was not adversely affected by cool grain. Recovery ratios of the 80:20 mixture throughout warm or cool grain were similar to applied ratios. There was little similarity to applied ratios in the case of the 75:25 mixture. (MQ 0-0-1(CCC))

4. Fate and Effects of Pesticide Residues. In PL 480 studies in Italy, malathion residues decreased slowest during storage in American Hard Red Winter wheat, intermediate on Italian durum, and most rapidly on Italian soft wheat. Residues were not detectable in the latter after 12 months' storage. When treated wheat was milled, very little malathion came through into the white flour. Most of it was in the bran and shorts. White flour contained only about 0.5 p.p.m. when milled from American Hard Red Winter wheat after being treated with 10 p.p.m. of malathion and stored for 1 year. The residue was negligible in flour from Italian durum and undetectable in that from Italian soft wheat. Bread contained only 8 to 16 percent of the malathion present in flour from which it was baked. Uncooked pasta contained only about 10 percent of the malathion present in flour from which it was manufactured, and no residue was detectable in cooked pasta. These results are of particular importance to the U. S. grain trade because European Common Market countries have been critical of malathion residues in our wheat. This report from one of their own countries says "... the use of malathion in the storage of wheat can be considered safe for the consumer."

In similar studies with methoxychlor, wheat treated with 27 p.p.m. lost only 0.2 to 0.4 p.p.m. during 6 months of storage. White flour contained 9 p.p.m., shorts 70, and bran 100. (E15-AMS-8(a))

5. Toxicology. By use of a newly-developed gas-liquid-chromatographic analytical method, EDB was found to be the only volatile compound remaining in materials treated with this fumigant. This indicates the absence of volatile reaction or degradation products. The largest amount of residual bromine was in lentils, which contained the largest amount of protein of the feeds tested. Addition of ascorbic acid or methionine to the diet of laying hens did not counteract the effects of EDB in reducing egg size and number. The cause of EDB effect on egg size does not appear to be directly hormonal. Prolonged feeding of EDB to mature cows did not affect conception and gestation, but in young heifers given EDB from birth, conception was delayed. Young cattle were affected by all doses higher than 2 mg./kg. The principal effect of EDB on ruminants appears to be on bull spermatozoa. The chief detoxication product of EDB in rat urine was identified as S(Beta-hydroxyethyl)-N-acetyl-cysteine. Feeding of EDB-treated mash to mature cocks did not affect volume of semen, sperm motility, or sperm concentration

after 2, 4, or 6 weeks of treatment. The histological effects of feeding EDB-treated food from calthood to full maturity were shown to be: (1) spermatogenesis was markedly reduced and, in many cases, completely ceased, (2) Sertoli cells seemed normal, while spermatogonia were in the resting stage, (3) most of the lumina of the tubules were empty or else filled with cell debris, (4) Leydig cells were normal, (5) in the caput and corpus epididymis, elongation of the columnar cells was found, which caused the epithelial lining to protrude into the lumen of the ductus, and (6) thickened connective tissue was characteristic all along the epididymis. (A10-AMS-4(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Hart, J. R., and C. Golumbic. 1965. The use of electronic moisture meters for determining the moisture content of seeds. Preprint, 14th International Seed Testing Congress, Munich, May. (MQ 3-23)

Baker, Doris, C. C. Fifield, and T. F. Hartsing. 1965. Factors related to the flour-yielding capacity of wheat. The Northwestern Miller, February. (MQ 3-36)

Quality Maintenance in Storage

Hart, J. R. 1964. Hysteresis effects in mixtures of wheats taken from the same sample but having different moisture contents. Cereal Chemistry, Vol. 41, No. 5, September. (MQ 3-23)

Prevention of Insect Infestation

Amir, D., and R. Volcani. 1965. Effect of dietary ethylene dibromide on bull semen. Nature 206(4979): 99-100. (A10-AMS-4(a))

Dal Monte, Gino. 1965. Studi sull' origine delle infestazioni di punteruoli nelle paste alimentari. (Studies on the origin of weevil infestations in pasta.) Agricoltura, Vol. 4, 9 pp. (E15-AMS-9(a))

AREA 4a

RICE - MARKET QUALITY

Problem. Harvested rice is subject to damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of disease organisms, and by insect infestation. There is need for developing more effective ways of preventing insect infestation during storage, handling, processing, packaging, and transportation of rice. Attention must be given to finding control methods that will minimize or eliminate pesticide residue hazards. To maintain the quality of rice, more precise information is needed on the changes that occur in handling, storage, and transportation. To insure uniform and standardized products and more equitable prices to all concerned, new and improved procedures for measuring quality factors must be developed for use in inspection, grading, and standardization operations.

USDA PROGRAM

The Department has a continuing program involving engineers, chemists, and plant pathologists in basic and applied research on the quality evaluation and quality maintenance of rice. This work is located at College Station, Texas, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort in this area totals 2.5 professional man-years: quality evaluation 0.5 and quality maintenance 2.0.

A grant to the Department of Plant Chemistry, Valencia, Spain, provides for a study on storage changes in milled rice and their relation to market quality. Its duration is for 4 years, 1964-1968, and involves P.L. 480 funds with a \$62,479 equivalent in Spanish pesetas.

There is also a continuing program involving entomologists and chemists engaged in basic and applied research on the prevention of insect infestation in rice in the marketing channels, headquartered at Fresno, California. The Federal effort of about 2 professional man-years was temporarily diverted during this reporting period to emergency research on the effects of gamma irradiation on stored-product insects, which is also pertinent to the problems of insect infestation in stored rice. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in stored rice.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations maintain a continuing but very modest program of research related to the market quality of rice. It involves evaluation of new rice varieties and lines for specific qualities through cooperation with the Regional Rice Quality Laboratory. Basic chemical and physical data relative to the quality of the rice and its protein, lipid, and starch components is sought. The variation in these constituents among several varieties and in relation to maturity at harvest is also investigated. Another study is concerned with the effects of infrared drying of rough rice on the quality of the milled rice.

The total State scientific effort devoted to market quality research on rice is 1.6 professional man years.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Degree of Milling of Rice. Light absorption and reflection properties of white and parboiled milled rice showed: (1) that the most effective method of measuring degree of milling is a measurement of the ratio of light transmittance at 850 m μ to that at 660 m μ and (2) color and degree of parboiling can best be measured by reflected light--the tristimulus value called "lightness." Measurements of degree of parboiling have shown that when samples are carefully graded by a number of inspectors and assigned numerical values representing true differences, the correlation between meter reading and visual grade is 0.935. These results substantiate the accuracy of the experimental lightness meter in predicting both color of white milled rice and degree of parboiling of parboiled milled rice. A commercial instrument manufacturer is now constructing the combination rice meter.

(MQ 3-16 (Rev.))

B. Quality maintenance in handling and packaging

1. Microbiological, Chemical, and Physical Deterioration of Rough Rice. Infrared drying of Century Patna rough rice lowered the equilibrium moisture

content during storage at 75% and 85% relative humidity an average of 0.3 - 0.4% over a period of 6 months. The rate of infection by storage fungi was significantly reduced by treatment with sodium propionate for 6 months in samples stored at 75% relative humidity and 4 months in samples stored at 85% relative humidity. Sodium propionate suppressed infection by Aspergillus candidus but did not control A. glaucus group spp.

Preharvest infection of Belle Patna rough rice by Helminthosporium oryzae did not materially affect the subsequent mycofloral succession during storage over a period of 385 days under marginal storage conditions (75% relative humidity at 30°C). Species of the A. restrictus series became the pre-dominant fungi, invading both H. oryzae infected kernels and fungus-free kernels. After 385 days, A. restrictus spp. were isolated from 90%+ of the kernels. Although total yields of brown and milled rice did not change significantly during the storage period, head rice yields decreased 2.7% in the lot with a 2% initial infection by H. oryzae in comparison to 4.4% in the lot with a 64% initial H. oryzae infection. There was also a decrease in the number of visually detectable damaged (discolored) kernels in brown and head rice in both lots.

The incidence of storage fungi in 207 lots of commercial rough rice of the 1964 crop from the 4-state southern rice area was determined and is given as the percent of lots from which the various major groups of storage fungi were isolated from a 100 kernel sample per lot: (1) A. flavus-oryzae group, 98%; (2) A. glaucus group, 95%; (3) A. niger group, 45%; (4) A. candidus group, 37%; (5) other Aspergillus spp., 12%; and Penicillium spp., 67%.

(MQ 2-7 (Rev.))

2. Mycotoxins in Rice. In a total of 729 samples of rough, brown, and milled rice assayed, 0.27% (2 samples) contained aflatoxins in concentrations greater than 50 ppb. Aflatoxins were not detected in 88.75% of the samples. In 77 randomly selected isolates of Aspergillus flavus-oryzae, twenty-two produced less than 5 ppb aflatoxin on sterile rough rice incubated 10 days at 30°C. The production by the remaining 45 isolates ranged from 5 ppb to a maximum of more than 500,000 ppb as determined by thin-layer chromatography on silica gel plates. Similarly, measurable amounts (max. 2957 ppb) were produced by 6 of 33 isolates of Penicillium spp. In a test with one isolate of A. flavus, more aflatoxins were produced on a substrate weight basis on ground brown rice than on ground rough rice, ground milled rice, rice polish, and rice bran. Other studies have indicated that rice is equal to peanuts as a substrate for the production of aflatoxins. Significant interactions, expressed in yields of aflatoxins have been observed between strains or isolates of fungi and peanut and rice substrates.

Non-sterile rough rice was inoculated with dry spores of a known high-aflatoxin-producing strain of A. flavus and stored at 30°C in relative humidities ranging from 70 to 100% for periods up to 4 weeks. The toxin concentration in the rice exceeded 50 ppb after one week in storage in relative humidities of 85% and above. At 80% and below, only traces of aflatoxins were detected during the entire storage period. The maximum concentration detected was in excess of 40,000 ppb after 2 weeks in 100% relative humidity.

(MQ 2-103)

C. Quality maintenance in storage

1. Storage Changes in Milled Rice. Initial experiments have indicated that changes in the molecular characteristics of the amylopectins and in starch content may be associated with aging and related changes in quality.

(E25-AMS-9)

D. Prevention of insect infestation

1. Nonpesticidal Control Methods. During studies on the effect of infrared drying on insects in rice, it was found that the variety of rice may influence the results. Final temperatures attained by Pearl, Calrose, and Belle Patna varieties varied after treatment with similar dosages of infrared radiation. This point is being investigated further.

(MQ 1-9)

A brief survey of the rice storage and milling industry operations in the Sacramento Valley of California revealed a general awareness of the importance of sanitation as a factor in preventing insect infestation. Carrying out good sanitation programs is apparently helping to keep insect infestations at a low level. This reduces the need for chemical control, which in turn helps to avoid pesticide residues.

(Exploratory)

2. Improved Pesticidal Control. American Cyanamid No. 47,300 was the only one of 5 candidate compounds found promising in preliminary laboratory evaluations of potential protectants for stored rice. It is receiving further testing.

(MQ 1-15)

The previously mentioned survey of the rice industry in California also revealed that pesticides were being used on a preventive maintenance basis to very good advantage. Such preventive use helps minimize more extensive pesticide applications that would otherwise be required as control measures.

(Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Primo, E., A. Casas, S. Barber, C. Bendito de Barber, J. Alberola y F. Pinaga. 1964. Factores de calidad del arroz XII. Metodo colorimetrico para la medida objetiva de la calidad de coccion. Rev. de Agroquimica y Tecnologia de Alimentos 4(1):102-108.

(E25-AMS-1(a))

Primo, E., A. Casas, S. Barber y P. Costillo. 1964. Factores de calidad del arroz XIII. Determinacion del grado optimo de elaboracion. Rev. de Agroquimica y Tecnologia de Alimentos 4(2):238-245.

(E25-AMS-1(a))

Johnson, R. M. 1965. Light reflectance meter measures degree of milling and parboiling of parboiled rice. Cereal Chemistry 42:167-174.

(MQ 3-12)

Quality Maintenance in Storage

Schroeder, Harry W. 1964. Sodium propionate and infrared drying for control of fungi infecting rough rice (Oryzae sativa) Phytopathology 54:858-862.

(MQ 2-7(Rev.))

Prevention of Insect Infestation

Tilton, Elvin W., and Robert R. Cogburn. 1964. Laboratory evaluation of Bayer 29493 used for the protection of rough rice against insect attack Proceedings Rice Technical Working Group, Davis, California.

(MQ 1-15)

AREA 4b

FEED AND SEED - MARKET QUALITY

Problem. Many methods of determining seed quality currently in use require too many man-hours, impose tedious work on the analyst, are incapable of high degrees of standardization, and do not provide accurate indexes of quality. Practical methods are needed for determination of such quality factors as mechanical purity, genetic purity, germination, vigor, weed seed content, and infection with disease organisms. The deleterious effects of high temperatures and relative humidities on stored seed are well known but little is known about the part played by storage molds, especially the minimum temperature - relative humidity combinations under which the storage molds survive in stored seed. There is urgent need to increase basic research which would serve as a basis for developing more practical methods of determining seed quality and for recommending improved practices of storing seed.

USDA PROGRAM

The Department has a continuing long-time program on seed research involving botanists, plant physiologists, plant pathologists, engineers, and chemists engaged in both basic and applied research on quality evaluation and quality maintenance of seed. This research is conducted at Beltsville, Maryland, and College Station, Texas, and by research contract with the Oregon Agricultural Experiment Station.

A P.L. 480 grant with the Instituto Biologico, Sao Paulo, Brazil, provides for a study of substrate moisture levels for germination testing of agricultural seeds. The project runs from 1962 to 1967 and involves \$31,016 equivalent in Brazilian cruzieros.

A P.L. 480 grant with Rijksproef-station, Wageningen, Netherlands, provides for a study of the health condition of seeds in commercial channels and development of methods suitable for routine testing for seedborne organisms. The duration of the project is 5 years, beginning 1963, and the total grant in Dutch guilders is the equivalent of \$55,777.

A P.L. 480 grant with Samenprufstelle, Munster, Germany, provides for a study of the biological and environmental factors affecting the physiological maturity of grass seeds. The duration of the project is 3 years, beginning April 1965, and the total grant in German marks is the equivalent of \$31,775.

A. P. L. 480 grant with Forschungsgemeinschaft fur Saatgutforschung, Reutligen, Germany, provides for a study of methods for maintaining the germination of seeds in storage and in trade channels. The project has a duration of 5 years, beginning April 1965, and the grant in German marks is the equivalent of \$52,338.

A P. L. 480 grant with Agricultural Research Station, Beit Dagen, Israel, provides for research to find a satisfactory invisible marker of seeds in commercial channels and for research purposes. The project runs for 3 years, beginning February 1965, and the total grant in Israeli pounds is the equivalent of \$45,640.

A P. L. 480 grant with Indian Agricultural Research Institute, New Delhi, India, provides for a study to evaluate the X-ray technique for detecting empty seeds in purity testing and for determining seed viability. Its duration is 5 years beginning November 1964 and the total grant in Indian rupees is the equivalent of \$37,464.

A P. L. 480 grant with the Israel Institute of Technology, Haifa, Israel, provides for a study to develop tests for nutritive value of cereal grains and feeds. Its duration is 4 years, 1960-1964, but an extension of two additional years has been approved. The project involves an expenditure of \$31,016 equivalent in Israeli pounds for the original 4-year period.

The Federal scientific effort devoted to research in this area totals 8.0 man-years of which 2 man-years are by research contract. A project on seed moisture determination was terminated (MQ 3-23).

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATION

Scientists at the State stations have engaged in the study of the market quality of feed and seeds for many years. The program is continuing and involves both basic and applied research.

Much of the research on feed quality is conducted in conjunction with the extensive program in animal nutrition. Quality of feed studies relate to determining keeping quality of feeds as influenced by methods of harvesting, storing, and handling of livestock feeds. Mechanical developments facilitating the mechanization of harvesting and handling feeds have led to consideration of alternate feed handling and storage methods and evaluation of their effects on feed quality. Attempts to store feedstuffs with a minimum loss of quality and nutritive value have led to study and development of routine methods for evaluation of vitamins A and D in feeds. Biological changes occur in feeds during storage and the relationship of these changes is related to deterioration of computer formulated, least cost feeds with quality, and nutritive value considered as important factors.

Seed quality research involves physiological studies on factors associated with seed deterioration, the sequence of biological changes in storage, storage factors affecting these changes, seedborne microflora, and the use of seed coatings to preserve quality. Testing procedures for germination, vigor, and stand-producing potential are receiving much research effort. Other work is being done on blending seeds for uniform quality.

Two regional projects have been organized by the States to coordinate research on seed problems, including quality considerations. In the Northeastern region under NCM-22, quick methods of determining varietal purity of alfalfa and red clover are sought through both field and laboratory experimentation. In the Western region under WM-35, much attention is given to developing and improving techniques for rapid estimation of such quality factors as viability of seed, germination, and purity.

The total research effort in this area is 20.6 professional man years; of which 1.7 is devoted to feed quality research, and 18.9 professional man years is devoted to study of post harvest physiology of seeds and objective measures of quality in seeds.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Mechanization of Purity Analysis. A treated seed inspection station and a vibrator separator were completed and construction specifications and blueprints prepared. An improved subsampler was developed. It appears to be as accurate as the Boerner divider but is self cleaning, thus avoiding accidental contaminations with seeds lodged in hidden areas of the divider. This subsampler has been "field" tested and will be used in future research.

(MQ 3-21(c) Rev.)

2. Seed Metabolism. Further examination of the ribosome system in the germinating seed has allowed the identification of the polysome (an aggregate of the ribosome) as the component responsible for protein synthesis. The shift from monosome (single ribosome) to polysome

accompanying imbibition, indicates that in this transformation resides the control of protein synthesis by the seed. Analyses by in vivo labeling have further confirmed that all steps prior to arriving at the ribosome as well as those involved in release from the ribosome are not rate-limiting. However, kinetic data from this process do not correlate with the kinetics of the monosome to polysome conversion suggesting a more complex process.

(MQ 3-32)

3. Determining the Purity of Certain Grass Seeds. A series of referee tests showed that with Bahiagrass seed: (1) there was slightly less variation in results obtained by the flotation method than by the official method, (2) for any one determination, the standard error was 1.03% for both hand and flotation methods, and (3) the accuracy of the flotation method was slightly influenced by sample purity level.

(MQ 3-39)

4. Development of Seed Germinator. Tests with a prototype model of the basic germinator under development have resulted in improvements and are being incorporated into a model that is now under construction and comprise: (a) more reliable temperature controller, (b) higher intensity, more uniform lighting of germinator, (c) reduction in the time required to alternate temperatures and extension of the temperature range, and (d) minimizing overshoot in cooling.

(MQ 3-48)

5. Processing Grass Seed for Laboratory Testing. A modified McGill rice sheller has been adapted for shelling grass seeds by replacing the steel fluted roll with one of hard rubber. This machine has shelled orchardgrass, sideoats grama, and little bluestem thus far, with little or no damage to the caryopses. Proper settings of the roll spacing has been determined for these grasses.

(MQ 3-54)

6. Seed Vigor. Respiration measurements detected injury caused by gamma-irradiation, heat, or freezing of moist seed in corn, and by chilling injury during imbibition in lima beans. Measurements made two hours after the start of imbibition detected the presence of injury, and in the case of heat-treated corn seeds, the test was a more sensitive index of seed quality than standard germination tests, as judged by field emergence. A general relationship appears to exist between initial respiration rates and subsequent seedling growth of corn.

(MQ 3-55)

7. Development of Methods Suitable for Routine Testing of Seed for Seedborne Organisms. The principal finding to date is that certain species of fungi grow faster and produce more easily identifiable colonies in germination substrata kept slightly dry than when left moderately moist or wet. While this did not hold true for all species of fungi, it should be of value to those seed testing stations which test flax seed for pathogenic fungi. It appears likely that the procedure can be used.

(E19-AMS-11(a))

8. Verification of Varietal Designations of Crop Seeds. Significant differences in protein banding on the acrylamide gel have been found between groups of varieties; however, these groups with different banding patterns can also be distinguished by morphological characteristics of the seeds.

(MQ 3-64)

9. Moisture Levels for Seed Germination. Based on dry weight of the seed, the initial water uptake, expressed as percent of the dry weight of seeds, was found to be essentially the same for rice and corn. Crotalaria and canavalia (swine bean) differed considerably from beans, corn, and rice. Earlier, it was stated that a correlation was found between the weight of seed of different species and water absorption. Additional research failed to confirm the earlier reports.

In general, it was found that abnormal seedlings caused by insufficient moisture recovered and produced normal plants but that most of the other abnormal seedlings failed to do so.

Some workers claim that the principal area through which water passes are the hilum and micropyle. It was found that the micropyle does permit some water to enter the seed but that the hilum is essentially impervious to the passage of water. There is a small band just outside the hilum through which water appears to pass relatively freely.

(S3-AMS-2(a))

B. Quality maintenance in storage.

1. Microbiological Deterioration of Grass Seeds During Marketing.

Relative humidity had no deleterious effect on seed germination when the storage temperature did not exceed 10°C or at 20°C and 35% or 55% relative humidity. Storage at 30°C was not harmful at 35% relative humidity but at 55% relative humidity a decrease in germination occurred between 8 and 12 months. Storage at 35°C and 55% relative humidity was deleterious when

the storage period exceeded 4 months, but when stored at 35°C and 75% or 95% relative humidity severe damage occurred after 2 months.

There appeared to be no close correlation between the decline in seed germination and the number of species of storage fungi belonging to the Aspergillus glaucus group that were recovered from the seeds. The fungi in this group tended to decrease in number with time. At relative humidities of 35, 55, and 75 percent, temperature had practically no effect on the relative humidity and seed-moisture-content relationship; however, this was not true at 95 percent relative humidity. Research aimed at production of fungus-free seeds has been initiated. Fungus-free seeds are almost essential as controls in the study of fungus effects on seed deterioration.

(MQ 2-62)

2. Gamma Radiation of Seeds. There was great variation in sensitivity to radiation injury among the crop species used. Germination of onion seed was reduced, or the emerging radicles injured at 5 to 10 Krads; whereas, the germination of crimson clover and radish seed was not reduced significantly at a dose of 80 Krads. In general, a low percentage of seeds of each seed lot was injured at the dose found to be the minimum for the species concerned; then injury increased as the dose was increased. There was no evidence that high moisture content of the seed (13.5 percent) protected it against radiation damage but there was an indication that low moisture content (5.0 percent) renders the seed more vulnerable to radiation damage.

Seeds that had been stored at 80 percent relative humidity and 21°C (95 percent relative humidity for peanuts) for a total of 16 months were assayed for the internally-borne storage fungus, Aspergillus amstelodami except that peanuts were assayed for A. flavus. Aspergillus amstelodami apparently died out in both the unirradiated and irradiated samples of radish (1963 crop year) and sorghum (1962 and 1963 crop years). The amount of A. amstelodami on seeds of peanuts, Kentucky bluegrass and onion decreased. In corn, no appreciable decrease was evident but there was a large increase in wheat.

(MQ 2-62)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Boller, R. A., J. N. Yeatman, and M. F. Combs. 1964. The effect of various sources of artificial light and of different backgrounds upon the grading of grain. Proc. Assoc. Offic. Seed Anal. 54:97-99.

(MQ 3-30)

Hart, J. R. and C. Golumbic. 1965. The use of electronic moisture meters for determining the moisture content of seeds. Proc. Internat. Seed Test. Assoc., 30. Preprint 5, pages 1-11.

(MQ 3-23)

Hartstack, A. W. 1964. An electrical conductance hay moisture meter. U. S. Dept. of Agric. Report 51-2.

(MQ 3-41)

Larsen, A. L. 1965. Use of thermogradient plate for studying temperature effects on seed germination. Proc. Internat. Seed Test. Assoc. 30. Preprint 68, pages 1-8.

(MQ 3-64)

Marcus, A. and J. Feeley. 1964. Isocitric Lyase Formation in the dissected peanut cotyledon. Biochem. Biophys. Acta. 89, 170.

(MQ 3-32)

Marcus, A. and J. Feeley. 1965. Protein synthesis in imbibed seeds. II. Polysome formation during imbibition. Jour. Biol. Chem. 240. 1675-1680.

(MQ 3-32)

Nittler, L. W., G. W. McKee, and J. L. Newcomer. 1964. Principles and methods of testing alfalfa seed for varietal purity. N. Y. Agric. Expt. Sta. Bul. 807. 46 pp.

(State Cooperative)
(MQ 3-39)

Stermer, R. A. 1964. Purity analyses of certain grass seeds by flotation techniques. Proc. Assoc. Offic. Seed Anal. 54:73-81.

(MQ 3-39)

Tempe de, J. and T. Limmond. 1965. The influence of substrate moisture on the results of seed health testing in blotter medium. Proc. Internat. Seed Test. Assoc. 30. Preprint 33, pages 1-9.

(E19-AMS-11(a))

Woodstock, L. W. (Abstract). 1964. Respiration of seeds in relationship to vigor. Rpt. of Proc., Eastern Exp. Station Collaborators' Conference on Post-Harvest Physiology. Oct. 1964. pp. 22-23.

(MQ 3-55)

Woodstock, L. W. and J. Feeley (Abstract). 1965. Studies of correlations between early rates of respiration and subsequent seedling growth in corn. Proc. Amer. Soc. Plant Physiol. (AIBS).

(MQ 3-55)

AREA 5

LIVESTOCK AND MEAT - MARKET QUALITY

Problem. To insure that grades are a true measure of palatability, a better understanding of the relationship between the physical and chemical properties of muscle and quality must be established. This information can then be used to devise objective methods for measuring the degree of tenderness, juiciness, and flavor in meat cuts.

The dominant method of merchandising meat in retail stores today is through the use of self-service display cases. Therefore, quality and appearance of the meat is of primary importance and research on maintaining meat quality and shelf life is a necessity for the success of this type of merchandising. Lighting conditions required to evaluate meat quality need to be defined so that the meat quality attributes can be properly assessed.

The maintenance of desirable meat quality during various transport techniques and the determination and evaluation of the various methods of shipping fresh meats to European markets are primary research needs if we are to expand our market for fresh meats.

USDA PROGRAM

The Department has a continuing program involving chemists and food technologists in basic and applied research on quality maintenance, and development of objective methods for quality evaluation of meat. This work is conducted at Beltsville, Maryland, partly in cooperation with the Animal Husbandry Research Division, ARS, and the Livestock Division, C&MS, and partly by contract with the Universities of Wisconsin and Missouri.

The Federal scientific effort devoted to research in this area exclusive of contract research totals 6 professionals divided as follows: quality evaluation, 5.0 and quality maintenance, 1.0.

A research grant to the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide or nitrogen on chemical and physical properties of refrigerated meats. Its duration is 4 years, 1963-1967, and involves P.L. 480 funds with a \$44,453.40 equivalent in Finnmarks.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research directed to increasing our understanding of the market quality of meat has been a continuing part of the State stations' research program. Both basic and applied research are involved.

Market quality research on meats begins with study of the influence of breeding, feeding, and management treatments with cattle, sheep, and swine on the carcass and meat quality characteristics. The objective is to determine the relationships of live animal and management factors to ultimate eating quality. Such live animal traits as birth weight, rate of gain, efficiency of gain by sire groups, body measurements such as depth and length of body, type, market weight, and grade are related to carcass traits such as loin eye area, muscling characteristics, amount and distribution of fat, yield of wholesale cuts, chemical composition and carcass value in an effort to define animal traits which influence carcass and meat quality.

Other research involves investigation of various pre-slaughter treatments on the carcass quality, organoleptic characteristics and market value of the meat. Special attention is given to tenderness of meats and the fundamental causes of toughness or tenderness in meats. Certain post-mortem factors including aging exert profound effects on meat quality and considerable effort is devoted to attempts to gain a better understanding of their effects.

Almost all of the studies involve a certain amount of work on methods since methodology is of vital importance in the study of quality factors. Development of objective criteria for evaluation of meat quality is a continuing goal and new and improved methods of defining the quality of meat cuts are constantly sought.

Further along the route to the consumer, concern arises as to the effects of processing and storage treatments on the quality of meat. The influence of maturity, marbling, methods of aging and processing and storage, packaging and distribution are all studied for possible effects on ultimate quality. Microbial quality, distribution of muscle proteins, and lipids, morphological features, amount of connective tissue, and cooking treatment are other factors considered in attempting to establish the total quality characteristics of meat. Finally, the relationships of raw and cooked meat quality to consumer preference are determined. These are in turn related to the carcass quality and market value of the live animal.

A total of approximately 17.7 professional man years are devoted to market quality research on meats.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. European Fresh Beef Shipments. This work in cooperation with the Transportation and Facilities Research Division, ARS, is to study techniques for shipping fresh beef to European Markets. Preliminary studies were conducted on: (1) refrigerated van containers, (2) American-flag refrigerated holds, (3) foreign-flag refrigerated holds and (4) banana boats. Various methods of stowing fresh beef in refrigerated ship's holds showed beef hung on racks constructed of wood uprights and steel pipes with one layer of beef quarters on the floor used more of the available load space, and delivered the fresh beef quarters in excellent condition. These studies indicate that it is possible to ship American fresh beef to European markets in excellent condition and at relatively low transportation costs.

(MQ 3-34)

2. Lighting Requirements for Evaluation of Meat Quality. This study is designed to survey and assess the present lighting conditions under which meat is graded. Preliminary data indicate considerable variation in the light intensities within a beef cooler where a meat grader determines the quality grade of beef.

(MQ 3-59)

3. Relationship of Marbling to the Palatability of Beef. Results to date indicate the phospholipid content of five different muscles varies from approximately 0.7% to 1.25% depending on the muscle. The variation in triglyceride content is considerably wider ranging from 1%-10% of muscle weight. Cholesterol content is roughly 0.5% of the total lipid extract and is related to the triglyceride content rather than to phospholipid content. The degree of marbling plus this type of information may provide a more objective method for quality evaluation.

(MQ 3-60)

4. Flavor Studies to Provide a Basis for More Objective Measurements of Meat Palatability. Both precursor systems and the compounds responsible for meat flavor are being studied in beef and lamb. A fraction has been isolated from untreated lamb fat that has a characteristic lamb aroma. The intramuscular fat is being studied to see if this lamb flavor resides solely in the depot fat or is characteristic of all lipids in lamb.

The differences in the fatty acid composition of lipids results in the formation of different types of carbonyl compounds when meat is cooked and these compounds are potent flavor contributors.

(MQ 3-61)

5. Objective Methods for Measuring Maturity. The proteolytic activity at pH 3.8 was determined in breast and thigh muscle of six sets of broilers ages 4, 6, 8, 10, 12, and 14 weeks. The results show that in young, rapidly growing birds proteolytic activity is high and decreases with maturity. The direct relationship found suggests that proteolytic activity is related or involved in protein turnover and/or synthesis. This research approach is being investigated as a means of determining maturity in meat animals. Disc electrophoresis of water soluble proteins extracted from chicken muscle of 4- and 6-week old birds gave protein patterns that were qualitatively and quantitatively different from patterns obtained from birds 8-to 14-weeks old; this study has been extended to beef muscle. These differences in patterns may provide a method for measuring maturity.

(MQ 3-62)

B. Quality maintenance in handling and packaging

1. Shelf-Life of Prepackaged Meats. A manual containing recommendations for temperature, humidity, sanitation, and handling procedures for fresh meats, prepared under USDA research contract has been published by the University of Missouri Cooperative Extension Service. Steps that a retailer can take to increase the display shelf-life of meat are presented in the manual. Laboratory tests showed that meat displayed at 30°F had significantly longer shelf-life, less weight loss, lower bacterial counts, and more desirable color than meats stored at 34°F or 38°F. Also prepackaged meat samples held in darkness prior to display had significantly better color and desirability scores than those samples displayed under 120 c.p. of light. Little differences were found in the myoglobin percent, however, in most instances the percent metmyoglobin was significantly less from meat samples held in darkness. There were no significant differences in bacterial counts between the two light treatments.

(MQ 2-75)

C. Quality maintenance during transportation

1. Effect of Atmospheres of Carbon Dioxide and Nitrogen on Properties of Refrigerated Meats. Investigations on meat samples stored in 10% and 20% CO₂ were reported. They showed that control meat samples had slime in 12 days and a spoiled odor at 19 days whereas slime was produced in 33 days under 10% CO₂ and in 40 days under 20% CO₂. Color of the control samples had greater metmyoglobin than those stored under atmospheres of 10% or 20% CO₂. Other levels of CO₂ and N₂ atmospheres are scheduled for future studies.

(E8-AMS-5(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Handling and Packaging

Naumann, H. D., W. C. Stringer, and P. F. Gould. 1965. Guidelines for Handling Prepackaged Meat in Retail Stores. Manual 64 Univ. Mo. Coop. Extension Service, Columbia, Mo. May.

(MQ 2-75)

Quality Maintenance During Transportation

Robertson, J. K. and K. E. Hoke. 1965. Transporting Fresh Beef to European Markets. An Interim Report. USDA, ARS 52-3, Jan.

(MQ 3-34)

AREA 6

OILSEEDS AND PEANUTS - MARKET QUALITY

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin and with insects developing resistance to protective pesticidal treatments suggest the desirability of a complete revaluation of handling and storage methods for farmers' stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi, insects, and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration while in the marketplace through improper aeration, drying, handling, and storing. Earlier studies conducted on the effect of artificial drying on peanut flavor and quality were not conclusive. In addition, studies on shelling of farmers' stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., research on peanuts is done at Albany, Georgia, College Station, Texas, and Raleigh, North Carolina, in cooperation with the Texas Agricultural Experiment Station and North Carolina State College.

A P.L. 480 grant with the Vallabhbhai Patel Chest Institute, University of Delhi, India, provides for a study of physiological and biochemical factors involved in the production of aflatoxin by Aspergillus flavus. The project runs from 1965 to 1968 and involves \$81,921.52 equivalent in Indian rupees.

A P.L. 480 grant with the Hebrew University in Israel provides for a study of the biology of the fungus Aspergillus flavus Link and its infectivity to plants and harmfulness to animals. The project (line project A10-CR-46) runs from 1963 to 1968 and involves \$129,250 equivalent in Israeli pounds.

The Federal scientific effort devoted to research in this program totals 5.0 professional man-years.

The Department also has a continuing program at Tifton and Savannah, Georgia, involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination, and of pesticide residues in peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service, the Transportation and Facilities Research Division, the Field Crops and Animal Products Research Branch, growers' cooperative associations, and various industry groups.

The Federal scientific effort devoted to research on prevention of insect infestation was 2 professional man-years during the reporting period. In addition, much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in stored peanuts.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

A considerable amount of the genetic, breeding, variety, and cultural research on oilseeds and peanuts has the ultimate objective of increased market quality. Other studies are generally directed to determining the influence of variety, stage of maturity, and harvesting and handling practices on the market quality of the oilseed crop.

In the case of peanuts, the breeding objectives relate to yield, disease, and insect resistance, local adaptation and trueness to market types. Studies more directly related to quality are concerned with the effects of fungi on market value of the seeds and the fermentation products produced by fungi growing on peanut substrates. Market quality studies relate to effects of mechanical harvesting and curing, temperature-time-moisture relationships on keeping quality and on the market value of peanuts as affected by changes in storage. The quality of processed peanut products is being studied and the relationship of maturity and curing practice to finished product quality is being determined.

Research which relates to the history and control of insects affecting peanuts, soybeans, and other oilseeds is reported in Area 13. Factors which affect soybean quality are involved in such breeding program objectives as improved resistance to disease, high oil content, and seed

quality. Illinois is evaluating the quality of soybeans and soybean products for human consumption. Missouri is studying genetic and environmental factors which affect the market value and quality of soybean seed for planting. Other research is directed to solving problems associated with storage and handling of oilseeds. For example, developments in the mechanization of castor bean production and handling are being investigated. Along with development on production, State stations study the effects of conditioning and storage upon market value.

Total market quality research effort on peanuts and oilseeds at the State stations is approximately 6.7 professional man years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. A cleaner for separating samples of farmers' stock peanuts into foreign material, loose shelled kernels and whole peanuts has been developed. The machine reduces the time required for an inspector to separate a sample of peanuts from approximately 10 minutes to less than 3 minutes. About 75 machines are being purchased by private industry for use by the Inspection Service in the Southeastern peanut area during 1965. The machine will be tested in the Virginia-Carolina area and in the Southwest during the 1965 marketing season.

A simple device has been developed to prevent peanuts from wedging in the opening between the inner and outer tubes on the pneumatic sampler. The device eliminates the necessity to periodically clean the peanuts from between the two tubes and should speed up the sampling operation. The device was developed and tested in cooperation with the Federal-State Inspection Service in Georgia.

A special seal for the roller adjustments on the peanut presizer has been developed and the presizer will be used as the official method for determining the percent fancy size in Virginia-type peanuts. Use of the presizer for this purpose will eliminate hand-screening of peanuts which is time consuming and highly subjective.

(MQ 3-29)

2. Evaluation of Damage Factors in Peanuts. Acetaldehyde, ethyl acetate, and ethanol, thought to be the main components of high-temperature off-flavor in peanuts but present in trace amounts in the 1963 normal-flavored peanuts, were not present in normal flavored peanuts from the 1964 crop.

The complete absence of these compounds is of particular importance since the occurrence of these compounds might be used on an index of high-temperature off-flavor. An active alcohol dehydrogenase system from peanut kernels has been isolated and shown to be active in crude preparations from peanut seeds.

A survey was made using gas chromatographic methods on runner and Spanish peanut samples which had been evaluated organoleptically to have an off-flavor or good-flavor by commercial standards. Qualitative and quantitative differences were observed between these peanuts from both runner and Spanish types. These findings, along with those from high-temperature cured Virginia type peanuts indicate that gas chromatography can be used as a useful quality evaluation tool on peanuts.

(MQ 3-26c)

3. Natural Antioxidants in Vegetable Oil Storage. Preliminary analysis of the data, prior to statistical interpretation, indicate that gossypol antioxidants are depleted rather rapidly in storage even at the lower temperatures, whereas, tocopherols require longer periods and higher temperatures for depletion. Also, increase in primary oxidation products occur comparatively rapidly when storage temperatures are above 90°F, with formation of secondary products earlier than previously expected.

(MQ 3-25)

4. Soybeans. A growing problem, particularly in the Southern States, involves the damage done by stinkbugs to soybeans. Preliminary chemical tests on lots of damaged and undamaged soybeans indicate that oil content is decreased and fat acidity increased as a result of the damage. A research contract has been let with the University of Arkansas for controlled experiments on this problem. The effort to find a chemical method for detecting stinkbug damage is continuing.

(MQ 3-65)

5. Distinguishing Soybean Particles from Foreign Matter. Samples of soybean particles and foreign material that pass through an 8/64th-inch grading screen were collected from grading offices throughout the United States. There were no marked differences in the composition of screenings from the various locations. Each area had the same types of weed seed and other foreign material in about the same proportions, about 79% foreign material and 21% soybean particles. Separation of the screenings through use of an electrostatic charge was not successful. The most successful method for separating the screenings employs the use of air flow to separate the light, chaffy material, and an inclined, vibrating surface to partially separate the weed seeds and soybean particles. By this method, one man can

separate 12 grams of screenings in about 10 minutes. Preliminary tests with knurled steel rollers indicate that soybean particles become imbedded in the knurls more readily than weed seeds. Tests on this method of separation for soybean particles and weed seeds have not been completed.

(MQ 3-24)

B. Quality maintenance in storage

1. Flaxseed Storage. Results indicate that in spite of molds, enzymes, and bacterial activity on seed in high-temperature high-humidity storage, the oil after refining, was of as good quality as oils from seed processed before storage. Seed stored at lower humidity had a similar increase in peroxide value as that of high humidity stored seed.

(E21-AMS-6)

2. Soybean Oil Storage. The most precise measure of determining decrease in quality was found to be the decrease of color of the refined oils and the decrease in refined color of the crude oils. Increase in peroxide value was directly related to decrease in refined color, and can be predicted based on the initial refined color and the refined color during storage. Moisture and volatile matter, regardless of initial content, approached a constant value, depending on location of storage. Most refined soybean oils increased in free fatty acids and most crude oils increased in refining loss during storage, depending on initial content, but rarely exceeded specifications of the National Soybean Processors Association.

Flavor panel scores of several of the stored refined oils after deodorization and aging at 60°C for 4 days were significantly related to storage peroxide value and to dimer content. Relationships between stored peroxide value and dimer content of the deodorized refined oils were highly significant both with free access and limited access to air during storage. Two marketing research reports are in process of publication based on data obtained from a 4-year study of stored once-refined, crude, and degummed crude soybean oils.

(MQ 2-44)

3. Development and Control of Mycotoxins in Spanish Peanuts. The concentration of aflatoxins in farmers' stock Spanish peanuts was related to pod perforation. Damaged kernels from pods with growth cracks contained aflatoxins in concentrations 2000 ppb; apparently undamaged kernels from such pods contained from 500 to 1000 ppb. No aflatoxins were detected in either damaged or undamaged kernels of Spanish peanuts from 3 locations assayed immediately after digging.

Aflatoxin concentrations were high and Aspergillus flavus-oryzae spp were the most prevalent fungi in peanuts stored experimentally at moisture contents of 23 to 34 percent. The development of A. flavus species and aflatoxins is regulated in part by competition with other fungi. The ability of other fungus species of the peanut mycroflora to metabolize aflatoxins was demonstrated.

Non-sterile farmers' stock and shelled Spanish peanuts were inoculated with dry spores of a known high-aflatoxin-producing strain of A. flavus and stored at 30°C in relative humidities ranging from 75 to 100% for periods up to 4 weeks. The toxin concentration in the shelled peanuts exceeded 400 ppb after one week in storage at 85% relative humidity but decreased to 36 ppb after 4 weeks. The toxin concentration increased to a maximum of more than 500,000 ppb after 4 weeks at 100% relative humidity. With farmers' stock peanuts, toxin concentrations exceeding 50 ppb were not detected until the peanuts had been stored for 4 weeks at 93% minimum relative humidity; at that time the toxin concentration was greater than 2,000 ppb.

(MQ 2-103)

4. Molds and Aflatoxin. Tests with peanuts inoculated with a toxic producing strain of Aspergillus flavus have shown: (a) the peanut hull helped prevent the production of aflatoxin in peanut kernels by mold; loose shelled kernels and kernels from broken hulls contained much higher levels of aflatoxin than kernels from sound hulls, (b) curing treatments presently recommended for Virginia-type peanuts prevented the production of aflatoxin if the peanuts were not badly damaged by toxic molds before the start of drying, (c) prolonged periods in the windrow at high moisture contents did not cause aflatoxin production in cool weather (average low of 60°F and average maximum of 70°F), (d) inverting the windrow so that the peanuts were exposed to the sun caused the peanuts to dry more rapidly and reduced the risk of mold growth and aflatoxin production, and (e) moisture contents between 15 and 30 percent were more conducive to aflatoxin production than higher or lower moisture contents, requiring about 50 hours at 90°F and 100 hours at 70°F. The major concentration of aflatoxin was in damaged peanut kernels with no significant difference between visible or concealed damage. Elimination of damaged and shriveled kernels significantly reduced the concentration of aflatoxin in contaminated lots of peanuts but there was no general correlation between damage and aflatoxin levels in farmers' stock peanuts.

(MQ 2-107)

5. Vegetable Oil Storage. Olive, peanut, and soybean oils were stored at 30, 40, and 55°C for one year. With increasing temperatures, the peroxide values increased and the increase was more rapid in the refined than in the crude oils. There was a tendency for the aldehyde values to increase, but no significant change in iodine value, acidity, or thiobarbituric acid. The pro-oxidant effect of metals, partially and totally immersed in the oils at

room temperatures, generally decreased as follows: copper, iron, zinc, tin, and stainless steel. The oils in partially filled bottles increased in peroxide value faster than oils in totally filled bottles when various colored screens were used. The catalytic effect of light was less than higher temperatures in the dark. There was no outstanding improvement in maintaining low peroxide value with any of the several colored screens tried.

(E15-AMS-12)

C. Prevention of insect infestation

1. Nonpesticidal Control Methods. Stainless steel towers (2.18 cu. ft.) containing shelled or farmers stock peanuts were purged with nitrogen or carbon dioxide at flow rates of 50, 100, and 200 ml./min. for 7 consecutive days. Adult red flour beetles were exposed in the towers at depths of 10, 22, 34, and 46 inches below the surface of the peanuts for 2, 4, and 7 days. Both carbon dioxide and nitrogen provided effective control (80- to 100-percent mortality) of the insects within 2 days when the gas was allowed to flow into the towers at 200 ml./min. At flow rates of 50 and 100 ml./min., carbon dioxide usually produced greater insect mortality than did nitrogen, even though the latter was more effective in purging the oxygen from the towers containing peanuts. There was greater insect mortality at the 46-inch depth in the peanuts than at the 10-inch depth, with the gases being introduced from the top of the towers.

Effective control (80- to 100-percent mortality) of red flour beetle adults and larvae, and of Indian-meal moth larvae was obtained in 14 days at 60°F and 64 percent relative humidity in a nitrogen-purged atmosphere when the oxygen concentration was reduced to about 1 percent, and in 7 days in a carbon dioxide-purged atmosphere when the oxygen concentration was reduced to about 7 percent and the carbon dioxide concentration increased to about 65 percent.

Two diatomaceous earths, Kenite and Perma-Guard, and 2 silica aerogels, Drie-Die SG-68 and Cab-O-Sil M-5, each at 3 different treatment levels on farmers' stock peanuts are included in intermediate-scale tests now in progress. Observations after the first 6 months of the test show that 10.5 lbs./ton and the two silica aerogels at 1.5 lbs./ton are as effective as the standard malathion treatment. Kenite-treated peanuts had the lowest percentage of insect-damaged kernels during the first 6 months of storage. Perma-Guard and the lower application rates of the other dusts were not as effective as malathion.

(MQ 1-27 (Rev.))

2. Improved Pesticidal Control. Diazinon at 5, 10, and 20 p.p.m. was equal to or better than the standard application of 52 p.p.m. of malathion in intermediate-scale tests of protective treatments on farmers' stock peanuts. The peanuts treated with 5 and 10 p.p.m. of diazinon contained

less than 1 p.p.m. after 6 months; those treated at 20 p.p.m. contained 3.4 p.p.m. Fenthion at 20 p.p.m. was nearly as effective as the malathion standard. Dichlorvos was highly effective for the first 3 months of the test, but protection was of short duration. Peanuts treated with 20 p.p.m. of dichlorvos contained only 1 p.p.m. after 1 month.

(MQ 1-27 (Rev.))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Schroeder, H. W. and L. J. Ashworth, Jr. 1965. Aflatoxins in Spanish Peanuts in Relation to Pod and Kernel Condition. *Phytopathology* 55:464-465.

(MQ 2-103)

Ashworth, L. J., Jr., H. W. Schroeder, and B. C. Langley. 1965. Aflatoxins: Environmental Factors Governing Occurrence in Spanish Peanuts. *Science* 148:1228-1229.

(MQ 2-103)

AREA 7

COTTON AND COTTONSEED - MARKET QUALITY

Problem. Technological advancement in production, harvesting, and ginning, of cotton brought on by mechanization has resulted in changes in the quality of cotton fiber which are not recognized by present methods of quality evaluation. Mill operators, both domestic and foreign, have reported that these changes have reduced the spinning quality of cotton, thus increasing processing costs and lowering the value of finished products. Precise information is needed on the processing performance and manufactured product quality of cottons which have been subjected to various production, harvesting, and ginning practices in preparation for markets. New and improved techniques, devices, and procedures for measuring quality factors of cotton fiber are needed to provide better grading and standardization of lint cotton, and indicate the true processing performance and manufactured product quality.

Cottonseed is subject to deterioration in quality and loss in value through fungus damage and contamination, normal metabolic changes, and instability of its oil constituents when exposed to the atmosphere. To maintain its quality, more precise information is needed on the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods for measuring quality factors need to be developed for use in inspection, grading, and standardization programs.

USDA PROGRAM

The Department has a continuing program involving textile engineers, cotton technologists, chemists, and engineers in basic and applied research on objective measurement and evaluation of quality of cotton fiber and on the quality evaluation and quality maintenance of cottonseed. The research is conducted at Washington, D. C., Lubbock, Texas, Auburn, Alabama, and at Clemson, South Carolina, in cooperation with Clemson University, and by research contracts with Clemson University, Texas Technological College and Auburn University.

The program includes the following foreign projects under P. L. 480: A grant to Centre de Recherches des Industries, Rouen, France, provides for an investigation of fiber maturity and breakage during mechanical processing of cotton, and the relation of these factors to processing performance and product quality. Its duration is 4 years, 1961-1965, and involves P. L. 480 funds of \$64,500 equivalent in French francs.

Another grant to the same institution provides for development of an instrument for homogenizing and orienting fibers in samples for cotton testing. Its duration is 4 years, 1961-65, and involves P. L. 480 funds with a \$47,000 equivalent in French francs.

A grant to the Fiber Research Institute, T.N.O., Delft, Holland, provides for a study of the influence of length properties on the mill processing performance of cotton. Its duration is 3 years, 1962-1965, and involves P. L. 480 funds with a \$58,000 equivalent in Dutch guilders.

The Federal scientific effort devoted to research in this area totals 20.2 professional man-years subdivided as follows: cotton 17.7, with 4.7 under research contract and cottonseed 2.5.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations are engaged in developing breeding stocks and varieties for both upland and long staple types of cotton. The influence of climate, cultural practices, and harvesting, and storage conditions on yield and quality of fiber received much research attention. Mechanical harvesting effects are evaluated by study of fiber properties and through spinning tests. Fiber samples from the breeding and cultural studies are submitted to State and Federal laboratories for testing of fiber and spinning properties. The Tennessee station is giving special attention to devising new and better tests and improving equipment for measuring properties now considered standard in fiber testing. One study is devoted to developing germination tests for cottonseed and measuring seed quality. Another deals with seed cotton moisture content and the effects on cotton fiber quality.

Cottonseed is evaluated for quality and nutritive value--of particular interest is the study of the chemical properties and biological significance of gossypol and gossypol protein complexes. The quality aspect relates to feeding value and quality of the meal for farm animals.

Approximately 12.1 professional man years are devoted to quality evaluation of cotton and cottonseed.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurements and evaluation of quality of cotton

1. Effect of Various Production, Harvesting, and Ginning Practices on Cotton Quality and Spinning Performance. These studies, in cooperation with other agencies, are being continued by the ARS Cotton Quality Research Station, Clemson, South Carolina. Results are as follows:

(a) 1963 Defoliation Study. Preliminary analysis made of the 1963 early harvested cottons were similar to the results obtained from the 1962 defoliation study, indicating that the differences in fiber and spinning

qualities between undefoliated and defoliated or desiccated cottons were very small, although yarn strength tended to be slightly higher and spinning end breakage slightly lower for the undefoliated cotton. Similar trends were noted for the late harvested cottons. The micronaire reading was lower for the late harvested cottons than the early harvested cottons, with the lower micronaire readings being obtained on the defoliated or desiccated cottons. A report for these two crop years is being prepared.

(b) 1963 Foreign Matter Study. This study was designed to determine the effects of foreign matter on spinning performance, product quality, and cost of raw cotton. Two methods of trash removal were used: (1) by varying the gin cleaning equipment and (2) by using card crusher rolls. The test results showed that trash removal during ginning caused improvements in spinning performance when no noticeable fiber damage occurred. The use of card crusher rolls to further remove foreign matter resulted in improvements in spinning performance and yarn appearance regardless of the ginning conditions. The greatest improvement was noted for the trashier or minimum gin-cleaned cotton. A progress report on this work has been published. This study will be continued for another crop year.

(c) 1963 Bale Compression Study. This study conducted under contract by Texas Technological College, indicated that the level of bale density had no effect on fiber quality but did affect the weight of stock produced in process during opening and picking. After adjustments were made to control weight at picking and at drawing, the level of bale density did not affect yarn properties or spinning performance. A report is being prepared.

(d) 1964 Pima Ginning Study. Preliminary analyses of test results indicate that a reduction in lint moisture during ginning caused a reduction in foreign matter content and in fiber length but resulted in improvement in spinning performance. The amount of cleaning equipment used in this study had very little effect on fiber and spinning properties. A report is being prepared.

(e) 1964 Southeastern Picker-Stripper Study. Preliminary analyses indicates that the spinning end breakage ranged from 3 to 5 times higher for stripper-harvested cotton than for the spindle-picked cotton. The data are being further analyzed and a report will be prepared.

(MQ 3-33(c))

2. Spinning Methodology Studies. A methodology study was designed to determine the effects of fineness, length uniformity, and card crusher rolls on spinning performance and yarn properties. The results showed that when crusher rolls were used, an increase in micronaire reading or a decrease in length uniformity ratio caused spinning end breakage to increase for both 30s and 40s yarn. The effects of fineness were greater for 40s than for 30s yarn, whereas the effect of length uniformity was essentially the same

for both 30s and 40s yarn. When the crusher rolls were not used, neither fineness nor length uniformity significantly affected spinning end breakage for 30s yarn. Evidently, trash content overshadowed the effects of fiber properties for 30s yarn. For 40s yarn, end breakage increased with increases in micronaire reading and with increases in "nep-like" fragments (trash) in yarn. For yarn properties, an increase in micronaire reading caused a decrease in yarn strength, and an improvement in yarn appearance. A decrease in length uniformity ratio also caused a decrease in yarn strength. The use of crusher rolls reduced spinning end breakage and yarn imperfections but had no effect on yarn strength. A report on this work has been released. These methodology studies will be continued.

(MQ 3-33c)

3. Investigation on Chemical Residues on Surface of Cotton Fibers. Techniques are being developed to better characterize the chemical nature of the cotton fiber surface in reference to chemical residues and inherent chemical composition. A practical, reproducible method for removal of cotton waxes was developed. During the year, many lots of cotton gave considerable trouble in spinning due to lap-ups and gumming of the rolls. A study was started to try to establish a relationship between the quantity and nature of the noncellulosic constituents of the fiber and the tendency to cause stickiness and lapping on spinning rolls. It was found that, in general, the low-micronaire cottons had high wax contents and a high percentage of alcohol-extractable materials, and these cottons lapped badly on the rollers during spinning. The low-micronaire cottons also lost much more weight in normal scouring and bleaching processes. Future investigations will include development and utilization of additional qualitative and quantitative techniques to aid in establishing relationships between the noncellulosic constituents of the cotton fiber and either spinning performance or product quality.

(MQ 3-42)

4. Measurement of Frictional Properties of Cotton Fibers. Work has continued on the development of methods for measuring drafting cohesion and short-term drafting cohesion variability. The use of multiple sliver feed has improved the testing efficiency. The electronic measuring system has been simplified and the cohesion tester has been redesigned to lower the inertia of the load-weighting system so that testing speed can be increased. Using this new technique for measuring drafting cohesion, card slivers from lots being processed in the Pilot Spinning Laboratory were tested. An analysis of the test results shows that drafting variability is related to fiber length variability and is related to measurements of yarn irregularity. A progress report is being prepared for publication.

(MQ 3-43)

5. Instrument Evaluation. Evaluation of the Fibrosampler and the Digital Fibrograph was continued. Suter-Webb array measurements, calculated on both weight and number basis, were compared with Digital Fibrograph measurements, which are on a number basis. The number of long fibers, rather than the weight of long fibers by array, was more highly related to break factor. The Digital 2.5 percent span length was as highly related to break factor as was the array upper quartile length. The weight of short fibers, rather than the number of short fibers by array, was more highly related to end breakage.

A manuscript is being prepared, giving suggested techniques for operating the Fibrosampler in order to maintain a constant level of test results on the same test sample with a minimum amount of testing error.

A progress report on the evaluation of the Outlook Trashmeter was prepared, jointly, with the Cotton Division, C&MS. Trashmeter measurements (4 observations per sample) were as good as Shirley Analyzer measurements in predicting picker and card waste and were more highly related to grade index than were the Shirley Analyzer measurements. The Trashmeter has good precision, but more than one reading per sample is necessary because of sample variation. Also, background color affects the level of the measurements.

(MQ 3-47)

6. Relationship of Fiber Maturity to Fiber Breakage During Mechanical Processing. Six bales of Acala 4-42 cotton representing 6 levels of maturity (micronaire readings) were investigated during this fiscal year and the results indicated the following:

1. Fiber breaking at reversals in the fibrillar structure is much greater for the mature cottons than for the immature cottons.
2. Spinning performance is more highly related to mean length of drawing sliver than to maturity of the cotton.
3. Fiber breakage during processing is much greater for the immature cottons than for the more mature cottons.

Two additional cottons are yet to be investigated.

(E9-AMS-4(a))

7. Instrument for Homogenizing Test Sample. A research project is being conducted in France under a P. L. 480 project to develop an instrument for homogenizing and orienting cotton fibers in a sample for fiber testing.

A number of approaches to this problem have been investigated without success. The latest developments involving two instruments look very promising. One instrument involves mechanical means only and the other a combination of mechanical, pneumatic, and electrostatic means. These instruments are being evaluated and preliminary results indicate that very good opening, blending, and parallelization is being obtained without noticeable fiber breakage.

(E9-AMS-5(a))

8. Influence of Fiber Length Distribution on Mill Processing. A research project is being conducted in Delft, Holland, under a P. L. 480 grant to study the influence of fiber length distribution on mill processing of cotton. The results obtained on the large-scale test showed that variants with cut fibers added gave higher number of end breakages at spinning than the corresponding variants with comber noils added for both the Acala and Deltapine cottons. In the case of the small-scale tests, the Acala variants gave the same trend as the large-scale test but the Deltapine variants gave the opposite trend. For weaving, the yarn breaks that can be ascribed to yarn itself is highly related to the number of weak spots in the yarn. Of all the yarn breaks, more than half of the total breaks were caused by the loosening of the knots. A paper dealing with this work was presented at the Cotton Research Clinic, held at Pinehurst, North Carolina, last February.

(E19-AMS-8(a))

B. Objective measurement of quality of cottonseed

1. Method for the Rapid Measurement of the Refining Loss of Cottonseed Oil in Small Lots of Seed. An estimate of the amount of refined oil obtainable from cottonseed by a fast instrumental method is dependent upon a standard method for reference. At present, the standard neutral oil method of the American Oil Chemists' Society appears to be the best available method to use as a standard reference. Essentially, the oils are stripped of their polar compounds by passing them through a column of activated alumina. The reproducibility of the neutral oil method was not good but was improved by using alumina columns deactivated with water to facilitate removal of polar compounds and phospholipids.

(MQ 3-45)

2. Re-evaluation and Improvement of Official Cottonseed Standards for Reflecting More Accurately the Value of Products Obtained from Cottonseed. During the past season, the new pneumatic cottonseed sampler with modifications was used for the first time. The method, now official, was used by one-fourth of all seed processors. More mills are installing samplers at this time.

A continued study of price relationships of cottonseed and cottonseed products indicate that the oil, meal, and linters factors now in use were satisfactory for reflecting the value of seed at product prices prevalent during the past year.

(MQ 3-51)

3. Effect of Storage on Molds and Aflatoxins in Cottonseed. Bolls of cotton were selected from plants in six fields of cotton, four of which were heavily contaminated with boll rot and two which were free. Aflatoxins were found in the seed from the bottom part of the plants in one contaminated field and in the bottom, middle, and top of plants in another field. Cottonseed from all six fields, after ginning, did not indicate the presence of aflatoxins. The ginned seed from these fields, after normal storage at oil mills for 30 and 60 days, did not indicate the presence of aflatoxins.

A survey was made of the presence of aflatoxins in the cottonseed being processed and the meal produced at 52 oil mills which were located in all cotton production areas. Weekly samples were obtained beginning the third week of December. Approximately one thousand cottonseed and an equal number of meal samples were assayed for aflatoxin content. There appeared to be no correlation between free fatty acids content of the oil in the seed with aflatoxins in seed or meal.

Intact seeds, hulls, and meats from cottonseeds selected from fields heavily contaminated with boll rot showed large amounts of Aspergillus niger and only a small amount of A. flavus. It was also found that the hulls were superficially infected with large amounts of A. niger and A. flavus but A. niger was apparently more deeply entrenched or was more resistant to the NaClO_2 pretreatment. The meats were heavily infected with A. flavus, some of it evidently rather firmly established. However, not much A. niger showed up.

(MQ 2-108)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurements and Evaluation of Quality

Mullikin, Robert A., and Franklin E. Newton. 1964. Effects of Cotton Fiber Length and Length Distribution on Combing. Textile Industries, Vol. 128, No. 9, pp. 131-133, September.

(MQ 3-33)

Graham, John. 1964. Now--A Practical Way to Measure Drafting Force. Textile World, Vol. 114, No. 10, 60-62, October.

(MQ 3-43)

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(MQ 3-1)

Carpenter, Frances. 1964. Array Vs. Fibrograph--Some Comparisons of Cotton-Fiber Length as Evaluated by the Suter-Webb Array and Digital Fibrograph Methods, in Relation to Spinning End Breakage and Yarn Strength. Textile Industries, Vol. 128, No. 12, 51-54, 64, December.

(MQ 3-47)

Garner, Warren E., and Robert A. Mullikin. 1964. Effects of Certain Drying Treatments in Ginning on Fiber Properties and Spinning Performance of Southeastern Cotton, Crop of 1960. PRR No. 85 - USDA,ARS, December.

(MQ 3-33)

LaFerney, Preston E., Robert A. Mullikin, and Walter E. Chapman. 1965. Effects of Defoliation, Harvesting, and Ginning Practices on Micronaire Reading, Fiber Properties, Manufacturing Performance, and Product Quality of El Paso Area Cotton, Season 1960-61. MRR No. 690 - USDA, ERS, ARS, January.

(MQ 3-33)

Parker, R. E., Edward H. Shanklin, and Scott C. Shaw. 1965. Hexadecyl Alcohol as a Spindle Moistening Agent for Mechanical Cotton Pickers. ARS-42-110-USDA, March.

(MQ 3-33)

Carpenter, Frances. 1965. Determining the Quality of Comber Noils with Fibrosampler Digital Fibrograph Combination. Textile Industries, Vol. 129, No. 4, 135-136, April.

(MQ 3-47)

Newton, Franklin E., Preston E. LaFerney, and Samuel T. Burley, Jr. 1965. The Effect of Trash on Cotton Processing Performance and Product Quality. Textile Bulletin, 32-39, May.

Chapman, W. E., and V. L. Stedronsky. 1965. Comparative Performance of Saw and Roller Gins on Acala and Pima Cottons. U. S. Dept. of Agric., MRR No. 695. June.

(MQ 3-33)

Webb, Robert W. 1965. Interrelationships Among Five Cotton-Quality Factors, Including Fiber Strength 1/8-Inch Vs. 0 Gauge, as Related to Yarn Strength at Three Staple-Length Levels. U. S. Dept. of Agric., MRR No. 684, May.

(MQ 3-17)

AREA 8

WOOL AND MOHAIR - MARKET QUALITY

Problem. Wool fineness, variability, and color are the most important quality characteristics in determining the grade and consequently the economic value of wool. However, present methods of accurately determining wool fineness and variability are slow and tedious and the causes of yellow coloration of raw wools are not known. The determination of wool fineness employing electronic devices to measure fineness of standard cut particles appears to offer the most practical and rapid methods of determining the fineness and variability in a raw wool sample, and the isolation and identification of the yellow pigments causing canary yellow stained wools appear to be necessary for determining the causes of yellow stained raw wools. Animal fibers in raw or manufactured form are subject to damage by several kinds of fabric insects, estimated to cause at least \$350 million loss annually. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information that can be used in developing better preventive treatments. The safety of several compounds now used for mothproofing wool has been questioned, and safer effective treatments are needed.

USDA PROGRAM

The Department has a continuing program involving chemists and engineers in basic and applied research on the quality evaluation and development of objective methods for quality evaluation of raw wool. The research is conducted at Beltsville, Maryland, and under a research contract with the Harris Research Laboratories, Inc., Washington, D. C.

Line Project MQ 3-69(c) covering a study of "Core-bore wool sample preparation for measuring wool fineness by Coulter Counter technique" was initiated during this period.

Under a PL 480 grant to the Shri Ram Institute for Industrial Research, Delhi, India, research is underway on the "canary coloration" of raw wools. Its duration is for 5 years, 1963-1968, and involves PL 480 funds with a \$98,454 equivalent in rupees.

The Department also has a continuing program headquartered at Savannah, Georgia, involving applied research in entomology and chemistry, directed toward the protection of wool and other animal fibers against insect damage. The research is conducted in cooperation with the Armed Forces Pest Control Board and various industry groups.

A research contract with the Harris Research Laboratories, Washington, D. C., is to investigate the physical and chemical factors affecting the sorbtion and retention of quaternary ammonium compounds by wool. The contract became effective in June 1965, is in the amount of \$29,400, and continues to December 1966.

The Federal scientific effort devoted to research on the prevention of insect infestation was 1.1 professional man-years. Some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in wool.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research related to the market quality of wool and mohair is in progress at the Kentucky, Montana, New Mexico, Texas, and Wyoming stations.

The Kentucky program is directed to determining the grade distribution of wool sold in Kentucky and analyzing the grade-price relationships in the various areas of the State. Similar work is involved in programs at the other stations. Montana researchers, for example, seek to determine the relationship of color of scoured wool and colored fiber content of grease wool to their combing performance and market value. Other research deals with the effect of fiber measurement on the price of wools. Research directed to measuring the effect of outdoor weathering on wool fabrics made from fibers with selected properties is also in progress. One Texas study seeks to determine present domestic and foreign attitudes toward utilization of mohair blended yarns and fabrics and relate these to market qualities.

Total research effort on wool and mohair quality is 3.4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. "Canary Yellow" Coloration of Raw Wool. Results indicate that pigments in the suint are the main cause of yellow coloration. Also, alkaline oxidation treatments cause yellowing and reduce the tyrosine and tryptophan content of the wool fibers; and yellow coloration enters the wool fiber when the grease content is low. (A7-AMS-12(a))

B. Prevention of insect infestation

1. Nontoxic Mothproofing Treatments. Of 53 candidate compounds tested, 7 poly-substituted nitrogen compounds gave protection against carpet beetle larval feeding, were resistant to removal by drycleaning, were relatively low in mammalian toxicity, and appeared worthy of further testing. Three organic tin compounds used as antimicrobial agents in textiles, paper, and leather were effective against carpet beetle larval feeding and were resistant to removal by washing and drycleaning. Crestonal acid, Morcomet X-862, and Nacconal SZA, all anionic surfactants, protected against clothes moth larval feeding. (MQ 1-26)

A final inspection was made of 3 stacks, each containing 16 rolls of woolen military uniform cloth impregnated with DDT during the sponging process. The treatment was $17\frac{1}{4}$ years old at the time of inspection and for $16\frac{1}{2}$ years had been exposed continuously to a heavy fabric-insect infestation. The treatment was extremely effective, permitting only slight insect damage on the outer few yards of the rolls. Untreated cloth in the test was damaged extensively.

The final inspection was made on another test where the cloth was impregnated with DDT and individual rolls placed in cartons. The treatment was $12\frac{1}{2}$ years old and the cartonized rolls had been exposed to heavy insect infestation for $9\frac{1}{2}$ years at the time of inspection, which revealed that the cloth was completely protected against insect damage. An official military publication stated the results of this research could save the Armed Forces more than \$1.5 million per year. (Unclassified)

2. Pesticide Residues. Five lots of domestic raw wool were analyzed for pesticide residues by gas chromatography. Aldrin at 0.017 to 0.19 p.p.m. and dieldrin at 0.33 to 0.48 p.p.m. were found in wool from California, Montana, New Mexico, and South Dakota. DDT at 15 p.p.m. was present in wool from Texas. Larvae of the black carpet beetle and webbing clothes moth fed readily on all lots of the raw wool. Previous research had established that much higher residue levels are required to prevent insect feeding. Hand scouring of the grease wool removed about 96 percent of the DDT and one-third of the aldrin and dieldrin. (MQ 1-29)

AREA 9

POTATOES - MARKET QUALITY

Problem. The many varieties of potatoes, the different areas of production and seasons of harvest and special storage and handling requirements for specific uses require a continuing program of research on handling, storage, transportation, physiology, wastage control and quality measurement. The increased demand for potatoes to be used for chips, frozen french fries and other processed forms has created special problems to prevent undesirable chemical changes due to low temperatures during storage and transport. The use of higher temperatures has brought on additional problems of moisture loss and of bacterial and fungal decay. Higher temperature storage also calls for control of sprouting, with increased emphasis on sprout inhibitors. Objective indices are needed to identify quality factors that are important for specific product usage and relate measurable characters of the raw product to quality of the processed product. Also needed are instruments for non-destructive detection and rejection of potatoes with internal disorders during grading.

USDA PROGRAM

The Department has a long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota, is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine, is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips is conducted by the Fresno, California station. The studies at Beltsville involve quality evaluation, sprout inhibitors and basic research. Studies on market diseases are conducted at Chicago and Belle Mead, New Jersey.

The Federal scientific effort devoted to research in this area totals 5.5 professional man years. Of this number 1.0 is devoted to objective measurement of quality, 0.5 to handling and packaging, 1.5 to storage, 0.5 to quality maintenance during transportation, 0.5 to postharvest physiology, and 1.5 to postharvest disease control.

Projects terminated during this period included: chemicals for control of sprouting. (MQ 2-31).

CURRENT PROGRAM OF STATE EXPERIMENT STATIONS

Market quality research on potatoes at the State stations is concerned with maintaining potato quality through the harvesting - storing - marketing process. Factors of potato storage such as volume of air and fan operation required to maintain a specific temperature; optimum ventilating time; effect of various storage temperatures on sprouting, specific gravity, and rotting; and the use of various sprout inhibitors are being investigated. Efforts are being made to develop and standardize a reliable objective method for evaluating potato texture, and to apply this in determining the effect of extended storage practices on textural quality of potatoes. Research is underway to design and evaluate instrumentation for sensing and controlling the concentration of O₂ and CO₂ in storage houses.

Fundamental studies include investigations of the biochemical and physiological factors which precondition tubers to different types of internal and external mechanical injury. Tuber respiration studies are designed to determine the effect of temperature and length of storage on chip color and quality of potatoes.

Disease investigations involve studies of potato scab, bacterial ring rot, other bacterial and fungal diseases, identification and control of potato virus diseases, and determination of the effect of such diseases on market quality.

Total market quality research effort on potatoes at the State stations is approximately 5.6 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Predetermining Processed Quality in Potatoes. Research relating characteristics of the raw product to quality, particularly texture of frozen french fries was conducted in cooperation with the Eastern Utilization Research Division. Thus far no relationship can be established between shear press readings of the raw, par fried, or reheated strips with textures of french fries as evaluated by a taste panel. (MQ 3-56)
2. Susceptibility of Tubers to Bruise Damage. Tests were made with an impact instrument to measure susceptibility of several Red River Valley potato varieties to injury at different stages of maturity. The index obtained with this instrument was reasonably well related to the actual damage during harvesting. (MQ 3-40)

Maine potatoes decreased in resistance to bruising from harvest through 20 weeks' storage, then increased in resistance through May. Other tests showed that tubers increase in resistance to bruising during the first hour when moved from 45° F. to 60°. (MQ 3-40)

B. Quality maintenance in handling and packaging

1. Mechanical Injury Incident to Sizing Potatoes into Storage. Damage and skinning of Red Pontiac potatoes increased slightly but consistently during sizing into storage. The dimensional shrink of tubers after about 6 months' storage was reasonably consistent over the 3 dimensions measured except when pressure bruises occurred. (MQ 2-78)

2. Stone Separation. Moving water was found to be an effective means of separating stones from B-size seed stock. Fluming, shipping, and field tests indicate that water had no detrimental effect on the quality of the seed with respect to breakdown in transit, disease development in the field, or yield. (MQ 2-93)

C. Quality maintenance in storage

1. Storage Temperature on Processing Quality. Effects of storage temperature on the processing quality of six potato varieties were determined at East Grand Forks. Continuous storage at 50° F. generally gave lighter flake color with less tendency to greying in some varieties than when the potatoes were stored at 40 or 45° followed by conditioning at 65°. Flakes of the Norgold Russet had some undesirable texture characteristics after storage of the potatoes at 40°. Only Kennebec and Irish Cobbler made acceptable chips and french fries, with some variation with storage temperatures; Bounty, Snowflake, Red Pontiac and Norgold Russet were unacceptable for these purposes. (MQ 2-69)

2. Methods and Rates of Ventilation on Quality of Maine Potatoes. Fusarium tuber rot, Verticillium -pinkeye rot, and soft rot were controlled with ventilation in both 38° F. and 45° F. bin storage and pallet box storage at 40°, 45°, and 50° F. However, pressure bruising and internal black spot were severe in the 45° F. bin storage and tended to increase in severity as the airflow rates were increased from 0 to 1.8 cfm/cwt. Weight loss during the storage period ranged from 3.8% in 0 cfm/cwt. to 5.3% at 1.8 cfm/cwt. at 38°. (MQ 2-92)

3. Control of Sprouting of Potatoes. At Beltsville, potatoes dipped in solutions of CIPC ranging from 0.10 to 0.25% were free of external and internal sprouts after 4 months' storage in ventilated drums at 61° F. Those dipped in concentrations ranging from 0.000005 to 0.05% developed appressed external sprouts and some internal sprouts. Untreated potatoes, not in the drums but in the same room, had fairly normal external sprouts and no internal sprouts. The growth retardant dimethylaminosuccinamic acid (Alar) used as a 30-second dip at 2000 ppm on Katahdin potatoes before storage did

not reduce sprouting.

In Maine, potatoes treated with a 5% dust formulation of CIPC as they were placed in storage had about $1\frac{1}{2}$ times as much decay and were considerably duller after washing than untreated potatoes. Much of the dullness of the treated potatoes was due to silver scurf.

Casoron (2, 6-dichlorobenzonitrile) at rates as low as 4 ppm gave good inhibition of sprouting on Kennebec, Pontiac and Norgold varieties stored in the Red River Valley. Casoron appeared to be more effective at 65°F. than at 55°. (MQ 2-31)

4. Storage in Modified Atmospheres. Potatoes stored in 95% carbon dioxide and 5% oxygen developed extensive black heart and breakdown within 50 days at 40° and 55° F. Those stored in 99% nitrogen and 1% oxygen had only a trace of black heart at 40° but large amounts at 55°. Potatoes stored in 5 and 10% oxygen, the rest of the atmosphere nitrogen, and those stored in air did not differ significantly in appearance or in color of chips produced after 100 days' storage. (MQ 2-71)

D. Quality maintenance during transportation

1. Transit Temperatures of California Potatoes. Potatoes harvested May 5th produced relatively dark colored chips after holding at several simulated transit temperatures from 50° F. to 75° for 5 or 9 days. Chip color was best in potatoes held continuously at 70° and 75° F. The relatively dark color of the chips produced from all these potatoes probably resulted from low preharvest air temperatures, which averaged 58° F. during the week before digging. Potatoes harvested May 19th and June 23rd produced chips of acceptable color when held for similar periods at temperatures as low as 50°. However, those held at 60° or warmer produced the lightest colored chips. Generally potatoes held at low temperature could not be reconditioned by holding an additional 4 days at 75° F. (MQ 2-55)

2. Heavy Loads of Maine Potatoes. A comparison was made between 50,000- and 60,000-pound rail carloads shipped in the fall under ventilation, in the winter under heater service, and in the spring under ice-refrigeration. No significant difference between loads was found in bruising or disease development in transit. This research has been completed and a manuscript has been prepared for publication as a Maine Agricultural Experiment Station Bulletin. (MQ 2-42)

E. Postharvest disease control

1. Prestorage Washing. Two experimental materials and a 5-minute water dip at 130° F. applied at harvest satisfactorily controlled lenticel infection which is a problem in prestorage washing. These materials and a 7-minute water dip at 130° F. were also effective when applied 1 month after harvest. (MQ 2-93)

2. Hot Water Treatment of Seed Potatoes. Whole B-size seed of three varieties dipped for 3 minutes at 130° F. were not adversely affected in transit or in the field, confirming previous results. Seed tubers infected with the new strain of Streptomyces scabies, dipped for 5 minutes at 130° F. produced tubers with less scab than untreated controls. Dipping tubers in 130° F. water for 7 minutes reduced silver scurf development in storage. A 5- or 7-minute dip at 130° F. before storage also gave satisfactory control of bacterial lenticel infection and produced potatoes that were bright after storage. (MQ 2-90)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Handling and Packaging

Hunter, J. H., J. B. Wilson, and J. C. Thibodeau. 1964. A Forklift Mounted Scoop for Bulk Potatoes. Maine Agr. Exp. Sta. Misc. Pub. 622. (MQ 2-93).

Wilson, J. B., J. H. Hunter, and M. E. Gallegly. 1965. Stone Separation in B-size Seed Potato Stock. Maine Farm Res. 12(4):10-15. (MQ 2-93).

Quality Maintenance in Storage

Akeley, R. V., Audia, W. V. and P. H. Heinze. 1965. Some Newer Potato Varieties and Their Chipping Qualities. Proc. Production and Technical Div. Meetings, Potato Chip Institute, Internatl. pp. 9-10. (MQ 2).

Hruschka, H. W. and E. J. Koch. 1964. A Reason for Randomization Within Controlled Environmental Chambers. Proc. Amer. Soc. Hort. Sci. Proc. 85:677-684. (MQ 2-31).

Johnston, E. F., H. V. Toko, and J. B. Wilson. 1965. Pallet Box vs. Deep Bin; a Comparison of Potato Quality. Maine Agr. Exp. Sta. Bull. 636. (MQ 2-35).

Porter, W. L. and P. H. Heinze. 1965. Changes in Composition of Potatoes in Storage. Potato Assn. of America Potato Handbook, 10:5-10. (MQ 2).

Sandar, N., A. M. Cooley and L. A. Schaper. 1964. Effects of Storage Temperatures of Red River Valley Potatoes on Flake Quality. U. S. Dept. Agr. ARS 74-30, National Potato Utilization Conf. Report 14:58-64. (MQ 2-69).

Wilson, J. B. and J. H. Hunter. 1965. Airflow Effect of Isopropyl N-(3-Chlorophenyl) Carbamate (Chloro-IPC) Applied to Bulk Bins of Potatoes. Amer. Potato Jour. 42:1-6. (MQ 2-31).

Postharvest Disease Control

G. J. Griffin. 1964. Effect of Chilling on Phenol Metabolism and Fusarium Infection of Cut Potato Tissue. Phytopathology 10:1275-1277. (MQ 2-64)

AREA 10

POULTRY PRODUCTS - MARKET QUALITY

Problem. Technological developments continue in the poultry industries and create many new problems relating to the market quality of poultry and egg products. Introduction of highly mechanized equipment and machinery plus new techniques in processing affect the absorption and retention of moisture of ready-to-cook poultry, the contamination of poultry and egg products by spoilage microorganisms, the physical damage to poultry carcasses, and the sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

USDA PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, and through a research contract with the University of Iowa, Ames, Iowa.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years, about equally divided between objective measurement and evaluation of quality, and handling, packaging, and storage.

Project MQ 3-22(c) "Effect of various disease syndromes on wholesomeness of market poultry" was terminated during this period.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations conduct a continuing program of research directed to improving or maintaining market quality of poultry products. A new regional project, NCM-40, Improving Acceptability, Stability, and Utilization of Poultry Products, includes portions of the work aimed at determining basic causes of quality losses and at finding methods for minimizing these losses. Development of methods of measuring quality and quality changes as well as evaluation of consumer acceptability of products also receives attention in the regional study. The regional effort is about equally divided between problems on eggs and on poultry meats.

A large number of studies related to determining the influence of genetic, environmental, and general management factors on the ultimate market quality are in progress. These studies often involve the team approach with both production and product scientists cooperating.

The consumption of ready-to-eat poultry and poultry food products has increased dramatically during the past few years. As a result, many investigations are concerned with study of the factors perceived by consumers as important quality attributes in fresh, frozen, and further processed items. With broilers, these studies relate mainly to factors of tenderness, flavor, and shelf-life; with eggs, interest has centered on shell quality, interior quality and functional properties. Several other studies are concerned with protection of product quality from the standpoint of public health or safety and wholesomeness.

The research effort devoted to market quality research on poultry products is about 30.9 professional man years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality measurement and evaluation of quality

1. Effect of Various Disease Syndromes on Wholesomeness of Market Poultry.

The relationship of post mortem lesions commonly accepted as criteria of septicemia to known stages of septicemia was studied. Correlation of selected lesions (degeneration of pericardial fat, degeneration of the anterior edge of the thigh, dark, and dehydrated muscle, markedly enlarged liver, markedly enlarged kidney) with septicemia was shown to vary with the lesion and the length of time the bird was in a septicemic state. A total of 17 trials (14 with chicken fryers, and 3 with turkeys) involving inoculation of birds at various ages with particular combinations of disease agents, and then determining the nature and severity of symptoms and lesions at the peak of infection and then at time of slaughter were completed. A final report was submitted and the project terminated. Several manuscripts have been accepted for publication.

(MQ 3-22(c))

2. Methods to Evaluate Shelf-Life of Eviscerated Poultry. Accuracy of Bacterial Sampling of Chickens.

The effectiveness of the swab method of determining microbial populations on surfaces of ready-to-cook chickens was shown to be dependent on the chicken part that was sampled. Total aerobic microorganisms were more predominant on thighs than on breasts or drumsticks of fryer chickens. There was no significant difference in the bacterial counts of swab samples from thighs, drumsticks, and breast between the right and left side of fryer chickens. There was no significant difference in bacterial counts obtained from several birds within a lot as long as the same part of each bird was sampled. A manuscript was prepared and submitted for publication.

A comparison of 2 standard methods for preparing dilutions for agar plate counts (successive 1:100 dilutions and successive 1:10 dilutions) indicated that there was no significant difference in "average" bacterial counts between the two methods. These studies were carried out on "drip" from two groups of ready-to-cook chickens stored at 34°F.

(Exploratory Work)

3. Detection of Chlorinated Hydrocarbon Pesticide Residues in Poultry and Eggs. Simplified procedures for analysis of poultry and egg products for chlorinated insecticide residues using thin-layer chromatography (TLC) were studied. Whole egg or yolk, either liquid or dried, was blended with carbon celite using ethyl ether, and the mixture was added directly to the columns, simplifying sample preparation. Use of suction speeded column flow without affecting results. Cleanup of residues in rendered chicken fat was successful on either carbon-celite or partially inactivated florisil columns. With TLC it was possible to detect 0.02 micrograms or less of DDT, DDE, DDD, dieldrin, endrin, methoxychlor, lindane or heptachlor epoxide in 0.5 g egg (fat basis) or 0.4 g chicken fat. Time required for the complete analysis was less than two hours for either type of sample. A manuscript was prepared and has been submitted for publication.

(MQ 3-70)

B. Quality maintenance in handling, packaging, and storage

1. Chilling of Eviscerated Broilers. The relation of time and temperature of commercial continuous chilling of fryer chickens to the bacteriological condition and shelf-life of the carcass was determined. Chickens removed from various locations along commercial chillers were examined bacteriologically in the plant and throughout storage of up to 15 days at 34°F. Chickens chilled to about 40°F in a length of a specified continuous chiller were not of lower bacteriological condition or shorter shelf-life than chickens chilled to lower temperatures in greater lengths of the same type of chiller.

(Exploratory Work)

2. Quality Retention of Eviscerated Poultry as Related to Method of Slaughter. The radioactive tracer (I^{131}) technique of mammalian blood volume determination was adapted for studies with chickens. Birds weighing 1,000 g contained about 11.6 percent of that weight as blood whereas birds weighing 2,000 g had blood volumes of about 7.3 percent of their body weight. Chickens slaughtered by six methods (standard cut, kosher cut, and standard cut following brain stick, CO₂ immobilization, physical stun, and electric shock) lost 35 to 45 percent of their total circulating blood during 90 sec. bleeding. Blood loss in both 90 and 300 sec. bleeding was greatest in the physically-stunned birds and the standard-cut birds.

Method of slaughter did not significantly affect the amounts of blood retained in breast, thighs, drumsticks, or wings, but did affect the amounts retained in various organs of the viscera. Manuscripts have been prepared and submitted for publication.

(MQ 2-81)

3. Radiation Pasteurization of Tray Packed Cut-Up Chickens. Statistical analysis of off-odor scores of stored irradiated (0.1 and 0.3 Mrad) chickens was completed. For chickens which had been irradiated in the fresh condition and subsequently stored at 34°F and 40°F, the analyses indicated that, on the average, over a 15-day storage period there were no significant differences in either raw and cooked off-odor scores between chickens irradiated at the two levels or stored at the two temperatures. This was also true for chickens which had been irradiated in the frozen condition and stored up to 12 days at the two temperatures. Chickens irradiated in the frozen state with 0.5 Mrad and subsequently stored either at -15°F or 40°F exhibited a greater degree of oxidative deterioration (raw off-odor scores TBA values) than either 0.1 Mrad or unirradiated control chickens. Storage of the 0.5 Mrad chickens for 27 days at 40°F produced higher TBA values than similarly treated birds stored at -15°F for periods up to 14 weeks. TBA values and off-odor scores of chicken legs from 0.1 Mrad and 0.5 Mrad irradiated frozen carcasses cooked at 180°F for 50 minutes and then stored at 40°F for 16 days were not significantly different from unirradiated controls.

(Exploratory Work)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

Mercuri, A. J., and A. W. Kotula. 1964. Relation of "Breast Swab" to "Drip" Bacterial Counts in Tray-Packed Chicken Fryers. J. of Food Science 29:854-858.

(Exploratory Work)

Sadler, W. W. and R. E. Corstvet. 1965. A Second Survey of Market Poultry for Salmonella Infection. Applied Microbiology 13(3):348-351.

(MQ 3-22(c))

Quality Maintenance in Handling and Packaging

Rowan, J. D. and A. W. Kotula. 1964. Portable Power Supply Simplifies Air Testing. Food Engineering 36:73.

(MQ 2-10)

Kotula, A. W., J. A. Kinner, and J. D. Rowan. 1964. Portable Sampler for Airborne Microorganisms. USDA Agric. Marketing, Oct. p.4.

(MQ 2-10)

Thomson, J. E. 1964. Effect of Polyphosphates on Oxidative Deterioration of Commercially Cooked Fryer Chickens. Food Technology 18(11):147-148.

(MQ 2-10)

AREA 11

TOBACCO - MARKET QUALITY

Problem. Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and potential end use. The price support program has resulted in a large buildup of stocks, some held for as long as 7 years, about twice the normal period for storage and aging. The long-term storage and the compact, dense structure of the tobacco as stored in hogsheads make insect control difficult. Repeated, heavy applications of fumigants or other control measures during extended storage has raised a question as to the extent and significance of residues that may be accumulated. Treatments applied during storage should be assessed further to be sure they are safe. Measures now used only hold insect populations in check and do little to reduce them or prevent them from becoming established. Attention should be given to the development of measures that will minimize or eliminate the use of chemicals, and at the same time eliminate or prevent infestations. To accomplish this it will be necessary to develop much more basic information than is now available on the ecology, physiology, and behavior of the insects that attack stored tobacco. Various fungi, bacteria, and viruses have ample opportunity to be associated with tobacco leaves. It is becoming quite apparent that the quantity of phenolic compounds is increased markedly in plant tissue, including tobacco leaf, diseased as a result of the activity of various pathogens. These substances may affect mammalian physiology. Quality research is needed to determine the changes that occur in the composition of tobacco leaf as the result of the metabolic activities of pathogens and to characterize the organisms that constitute the nonpathogenic microflora associated with tobacco leaves.

USDA PROGRAM

The Department has a continuing program headquartered at Richmond, Virginia, involving basic and applied research in entomology and chemistry, directed toward the insect problems of tobacco and tobacco products in the marketing channels. The research is conducted in cooperation with farmers' cooperative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department. Two retirements and the inability to find qualified replacements has reduced the current Federal scientific effort on the prevention of insect infestation to 1 professional man-year. Some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," also applies to the insect problems in stored tobacco.

The Department is conducting quality research under contract and cooperative agreement with the Agricultural Experiment Station of the University of Kentucky, Lexington, Kentucky.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Scientists of the State agricultural experiment stations are engaged in basic and applied research related to tobacco quality. Much attention is given to smoking quality determinations on varieties, and on tobacco subjected to a wide range of management practices. Other basic studies concern objective methods for determining smoking quality, the chemistry of curing, fermentation processes to provide specific types of tobacco leaf, and the measurement of physical properties.

Use of machines and machine methods in tobacco harvesting and handling is expanding. Research is directed to determining the effects of mechanization procedures on quality. The Puerto Rico station has a study on tobacco quality which is aimed at determining standards of quality in tobacco and correlating these with preferences of cigar smokers.

The total program involves 11.9 professional man-years for quality related research on tobacco.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Prevention of insect infestation

1. Nonpesticidal Control Methods. The tobacco moth was found to be extremely susceptible to the vacuum-steam flow process. It is considerably more sensitive than the cigarette beetle. All larvae and pupae of the tobacco moth were killed by this treatment in a 5-minute exposure at 120° F. A 25-minute exposure is required for a comparable kill of the cigarette beetle. A 1-minute exposure at 130° F. killed larvae and pupae of the tobacco moth. It requires 140° F. for the cigarette beetle. The eggs of the tobacco moth are more resistant to the treatment. (MQ 1-37)

2. Biology and Ecology. Tobacco moth larvae did not live more than 3 weeks at a relative humidity of 30 percent and temperatures of 70, 80, or 90° F. At 40 percent relative humidity a few larvae lived for 6 months but none pupated. Moths completed their life cycle at relative humidities of 50 or 60 percent at all three temperatures. The greatest emergence of adults was at the higher humidity, but was poor under all environmental conditions of the test. Larval development was more rapid at higher temperatures, but larvae became larger at the lower temperatures. (MQ 1-7)

3. Improved Pesticidal Control. Seventeen candidate compounds were evaluated in the laboratory for residual and vapor toxicity against the cigarette beetle. Two were sufficiently effective to warrant further investigation. A third compound was not quite as effective but will receive further attention because of its specificity, rapid loss of residual effect, and extremely low mammalian toxicity. None of the 17 compounds had much repellent or attractant effect. (MQ 1-35)

An experimental control procedure has been followed in 5 tobacco warehouses since 1962. It involves hydrogen cyanide fumigation early in the spring and dichlorvos aerosol applications twice a week during the active insect season. Not a single tobacco moth has been trapped in these warehouses since the program began. Cigarette beetles trapped in the 5 warehouses in the entire 1964 season totaled 2, 8, 23, 99, and 527. The latter warehouse contained old-crop tobacco. Control has been good to excellent, but there has been a slight increase each season in the number of beetles trapped in some of the warehouses.

In an effort to develop an even better program, a tobacco warehouse was fumigated with hydrogen cyanide and daily applications of dichlorvos aerosol have been made during the insect seasons. Only 11 cigarette beetles have been trapped in this warehouse since the beginning of the program. It is not certain whether they had developed in the warehouse or were chance migrants. Two more warehouses were added to this program in the spring of 1965 and no beetles had been trapped in either by August 1. (Unclassified)

4. Pesticide Residues. Dichlorvos was found only in trace amounts in tobacco from a warehouse where there had been an application of 0.5 gram of dichlorvos in aerosol form daily for 5.5 months. Samples for chemical analysis were taken from the perimeter of a hogshead directly beneath the dispersion pattern of the aerosol nozzle, where the residue would be expected to be the greatest. (MQ 1-33)

B. Quality maintenance

1. Effect of Post-Harvest Microflora on Tobacco Composition. Under contract and cooperative agreement with the Kentucky Agricultural Experiment Station, research has been initiated to identify the microorganisms that constitute the microflora associated with tobacco, to determine their life cycles, enzymatic capabilities, metabolite production and effect on composition of tobacco. (MQ 2-109)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation

- Childs, D. P. 1965. Effect on the cigarette beetle of flowing steam vapor under vacuum. Tobacco Science IX: 56-60, (Tobacco 160(14): 32-36).
(MQ 1-37)
- Childs, D. P., J. W. Mooney, and Tom Gentry. 1964. A mechanical method of retaining the cigarette beetle on a test surface. Jour. Econ. Ent. 57(6): 839-840.
(MQ 1-35)

AREA 11 b

CUT FLOWERS AND ORNAMENTALS - MARKET QUALITY

Problem. The rapid increase in production of field-grown narcissus, gladiolus, lilies, stocks, and chrysanthemums into a multimillion dollar business in Florida, California, and other states has raised many problems in marketing. Methods of packaging, as related to cooling and market life, temperature requirements during transport and for limited storage periods, atmosphere modifications for storage and transit, and the control of Botrytis rot are among the most urgent research needs.

USDA PROGRAM

The Division has a limited program in market quality research on cut flowers and ornamentals, amounting to approximately 2.0 professional man-years. This research is conducted at the Fresno and Beltsville laboratories and at the Gulf Coast Experiment Station under a cooperative agreement with the Florida Agricultural Experiment Station. The California work is supported in part by the California Floral Traffic Conference and the California Florist Association.

Projects terminated during the year included: Maintenance of quality in cut flowers in ornamentals during transit, storage and marketing. (MQ 2-15)

PROGRAM OF STATE EXPERIMENT STATIONS

Market quality research on flowers and ornamentals at the State stations includes research on the storing and packaging of woody ornamentals; the storing and handling of evergreen nursery stock; and other storage studies with ornamental plant material to determine temperature tolerance of plant parts and species, to relate humidity, temperature, air movement, and type of storage wrapper or container to drying out, to determine the effect of storage atmosphere and light upon successful keeping and subsequent growth, and to develop improved storage techniques.

The relation of respiration to development, senescence, and keeping quality of flowers is under investigation. Such research is designed to establish respiration curves for flowers of certain ornamental plants during floral development and senescence; to investigate the influence of temperature on respiration rates, storage life and keeping quality of cut flowers; and to investigate the value of chelating agents and preservatives for modifying respiration and extending storage and keeping quality of flowering plants. Other factors receiving study in connection with the keeping quality of cut flowers are the pH of the holding solutions, humidity, air movement, and ethylene and carbon dioxide accumulation in storage chambers.

Grades and standards for cut flowers are being studied in connection with regional project NCM-35, Market Grades and Standards for Specified Cut Flower and Potted Plant Crops. Included for study in this project are roses, chrysanthemums, Easter lilies, poinsettias, and snapdragons.

Total market quality research effort on cut flowers and ornamentals at the State stations is approximately 9.6 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality maintenance in handling and packaging

1. Controlled Atmosphere Packaging for Roses. A polyethylene bag perforated with 24 pin holes and holding 100 blooms provided desirable atmospheres for roses during simulated air-transit conditions of 50° to 60° F. for 30 to 40 hours. Initial oxygen levels in the bag were lowered to 3 to 6%. Use of an unperforated bag resulted in oxygen levels of 1 to 2%, which were injurious at these temperatures. A test shipment of roses was made from San Francisco to New York and return (26 hours), using an upright carton with four compartments, each holding a bag with 100 roses. The oxygen level at the end of the trip was 5% and the quality of the blooms was excellent, with very little physical or other damage to the flowers. (MQ 2-105)

2. Narcissus. The shelf life (during 48 hours holding at 70° F.) of King Alfred daffodils was not lengthened by including 100 to 2000 ppm dimethylamino-succinamic acid (Alar), or 1 percent dimethylsulfoxide (DMSO) in the vase water. (MQ 2-15)

3. Snapdragons. Adding 10 to 1000 ppm Alar to the vase water did not increase the shelf life of snapdragons during a 1-day holding period at 40° or 70° F. Packaging snapdragons in perforated polyethylene bags for 3 days markedly increased flower abscission, presumably from accumulated ethylene. (MQ 2-15)

B. Quality maintenance in storage

1. Controlled Atmosphere Storage of Roses. Low oxygen atmospheres (1/4 or 1/2%) retarded petal opening of cut roses and blueing of red varieties, but slight injury occurred in some blooms held in these atmospheres for 3 weeks at 32° F. One-half percent oxygen was the most satisfactory of the low oxygen atmospheres tested. The addition of 5% CO₂ to low oxygen atmospheres curled the tips of petals slightly and increased blueing of some varieties. (MQ 2-105)

2. Controlled Atmosphere Storage of Carnations. The storage life of carnations was extended to 4 to 5 weeks by holding the flowers in an atmosphere of 0.5% oxygen. Petal color was well preserved and spread of Botrytis decay was reduced. Adding 5% CO₂ to the above atmosphere was of no distinct benefit. A temperature of 36° F. maintained carnation flowers in better condition than 32° during 4 to 5 weeks' storage. Red carnations tended to bleach when stored at 32°.

Commercial storage of carnations in controlled atmospheres (0.5 to 1.0% oxygen) has been developed in a pilot operation in cooperation with a grower and shipper. Accumulation of 1 to 2% CO₂ caused no undesirable effects. Temperatures were maintained at about 36° F. The shipper has found CA to be a great aid to his marketing program. (MQ 2-105)

3. Controlled Atmosphere Storage of Daffodils. King Alfred daffodil flowers stored in 100% nitrogen at temperatures from 32° to 70° F., had a longer display life at 70° than those stored at comparable temperatures in air. Daffodils stored 3 weeks at 32° in nitrogen lasted 40 hours longer than those stored in air. When stored 2½ days at 70°, those in nitrogen lasted 64 hours longer than those stored in air. Storage in 99% nitrogen and 1% oxygen was somewhat less effective than 100% nitrogen. (MQ 2-105)

C. Postharvest disease control

1. Carnations. Decay of carnation blooms inoculated with Botrytis cinerea was effectively controlled with a 2,6-dichloro-4-nitroaniline (Botran) or 2-aminobutane bicarbonate spray. The latter material was also effective as a volatile when applied by a pad containing the fungicide. Botran left an unattractive residue on the flowers. Slight injury to some flowers treated with 2-aminobutane bicarbonate occurred when either method of application was used. Captan, 2-aminobutane acetate, or dibromotetrachloroethane (DBTCE) were not effective in controlling Botrytis decay of carnations. (MQ 2-105)

2. Mistletoe. Aspergillus sp. was the predominant fungus observed in packaged mistletoe in 1964-65. It was particularly severe on leaves and twigs. Inoculations of leaves and twigs were successful only after tissues had first been injured. Histological studies show fungus hyphae to be intra or intercellular. No evidence was obtained that infection of leaves occurs through stomata. (MQ 2-15)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Storage

Asen, Sam, C. S. Parsons, and N. W. Stuart. 1964. Controlled Atmosphere for Storing Flowers. Florists' Exchange 141(24):30, 45, 54; also Southern Florist and Nurseryman 78(16):12-13. (MQ 2-105)

AREA 12

VEGETABLES - MARKET QUALITY

Problem. Most fresh vegetables are highly perishable. Research is needed on sources of inoculum and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening and aging. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Safe and effective transportation can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market. The increasing interest in liquid gases for transit refrigeration and atmosphere modification has posed a series of new problems relating to effects on the commodities from release of substantial amounts of nitrogen or carbon dioxide in the load compartments. Additional information is needed on objective indices for harvest maturity and quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels.

USDA PROGRAM

The Department has a continuing program of applied and basic research relating to quality measurement and protection of vegetables as they pass through marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Md.; Fresno, Calif.; Miami, Fla.; Orlando, Fla.; Belle Mead, N. J.; Chicago, Ill.; and Harlingen, Texas, and at the North Carolina Agricultural Experiment Station, Raleigh, N. C.

Of the 16.2 federal professional man-years devoted to this program, 2.2 are devoted to objective measurement of quality, 3.5 to quality maintenance in handling and packaging, 0.5 to storage, 3.0 to transportation, 3.0 to post-harvest physiology, and 4.0 to postharvest disease control.

Projects terminated during this period included: modified atmospheres, containers and transit services on asparagus (MQ 2-13); maintaining quality of vine-ripened tomatoes (MQ 2-23); translucent scale of onions in California (MQ 2-56); market quality of western lettuce (MQ 2-58) (related work on lettuce during transit is being conducted under MQ 2-84); market diseases of cucurbits (MQ 2-59); bacterial soft rot of peppers (MQ 2-87); and evaluating quality of tomatoes for processing (MQ 3-15).

CURRENT PROGRAM OF STATE EXPERIMENT STATIONS

Numerous projects at the State stations are concerned with the market quality of vegetables. Research includes studies of methods of cleaning vegetables; studies of methods of quality separation of vegetables; investigations of the effects of transit, storage, prepackaging, and retail handling treatments on market quality; development of packaging methods and materials; studies of senescence and microbe-inhibiting chemicals; hydrocooling; consideration of optimum storage environments including modified atmosphere storage; the investigation of the effect of temperature on the ripening of vegetables; and studies of the influence of storage environment on chemical and physical changes in vegetables. Pathological research involves transit, storage, and market diseases which affect the quality of vegetables.

Total market quality research effort on vegetables at the State stations is approximately 33.1 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Sweetpotatoes. Of 6 varieties harvested at 3 2-week intervals, Copperskin Goldrush had the lowest fiber content and L-9-66 and L-8-92 the highest. Date of harvest seemed to have little consistent effect on fiber content. No relationship could be established between fiber content and shear press peak value of either the raw or canned roots. In 1964 but not in 1963, both reducing sugars and sucrose increased as harvest was delayed. In most cases, curing resulted in an increase in reducing sugars. In 1964, neither curing nor time of harvest seemed to have any consistent effect on carotene content. In 1963, the carotene content increased during curing and roots from the early harvest had lower carotene than those from the midseason or late harvest. Carotene content correlated well with the internal color of the raw, canned, and baked roots. The Hunter a_L value seemed to be the best for estimating carotene content of the roots. Curing resulted in a softer canned Gem in 1964, whereas all 6 varieties were softer when canned after curing in 1963. In 1964 a softer product was obtained as harvest was delayed. The Asco Firmness Index correlated well ($r=0.844$) with subjective ratings but correlated poorly with shear press peak value. (MQ 3-50)

2. Tomatoes. This study of the new USDA tomato inspection procedure was a broad survey of the color of tomato juice from many manufacturing areas of the United States. The relationship of color parameters of processed juice to visual scoring again showed excellent agreement with the Tomato Color Index originally specified for fresh tomato juice. Apparent viscosity and insoluble solids were determined, with wide ranges in readings obtained for these quality factors. Perfect correlation was obtained between the Cal-Lab and Brookfield viscometers. (MQ 3-15)

B. Quality maintenance in handling and packaging

1. Lettuce. Under simulated shipping conditions (8 days at 32°, 37°, or 41° F.) the external appearance of commercially wrapped lettuce was generally slightly better than that of naked heads. In actual shipping tests to the New York market, external appearance was similar in wrapped lettuce and naked heads trimmed after arrival. Discoloration of the cut stem and physical damage were more severe in the naked than in the wrapped pack. Quality loss during a simulated retail period (4 days at 50° F.) was about equal in wrapped and naked lettuce.

Newly received western lettuce and selectively harvested New Jersey and New York lettuce were trimmed and prepackaged in each of 4 different perforated and non-perforated plastic films. They were then held for 4-5 days at 60° F. under relative humidities approximating 50, 70, and 90 percent. Weight losses and decay development during the holding period generally were inversely related. At 50 percent relative humidity, the most decay developed in lettuce prepackaged in the least permeable films, particularly in those lots sprayed with *Botrytis* spore suspensions. Incidence and severity of decay increased as humidity increased; particularly in lettuce wrapped with perforated films. More decay usually developed in lettuce when the film overwrap was heat-shrunk than when it was not. While perforations facilitated water vapor transmission and reduced decay, trimming losses due to wilting frequently exceeded decay losses at the lower humidities. (MQ 2-84)

2. Rhubarb. Rhubarb cut into 10-inch pieces, packaged in perforated polyvinyl chloride film and heat-shrunk had about the same market life (1 day at 70° F. following 5 to 7 days at 32°) as 1-inch stalk pieces in perforated 10-ounce polyethylene bags. Both had better market life than non-packaged controls. (MQ 2-61)

C. Quality maintenance in storage

1. Asparagus Plants. Trimmed (4 to 8 inches from the crown) and untrimmed asparagus plants stored for 3 months at 32° F. in polyethylene and planted immediately after storage did not differ significantly in a 4-year yield test. When stored in burlap bags the 4-inch trimmed plants produced less than those trimmed to 8 inches. Plants stored in burlap lost more weight during storage than those in polyethylene but when held 6 days at 60° after storage and before planting, non-trimmed plants stored in polyethylene had more decay and yielded less than those stored in burlap. Trimming roots before storage reduced the stored weight by 16% for the 8-inch and 40% for the 4-inch trimmed plants. (MQ 2-89)

2. Sweetpotatoes. Isopropyl-N(3-chlorophenyl) carbamate (CIPC) applied as an aerosol for sprout inhibition into the top of a bin of sweetpotatoes stored in bushel baskets caused residue levels to exceed permissible tolerances near the aerosol applicator but provided satisfactory control of sprouting. Application as a fog with commercial equipment gave fairly uniform distribution of

CIPC throughout the roots in palletized field boxes. Residues were within the tolerance but sprouting was reduced only about 50 percent. During 5 months of storage residues decreased approximately 50 percent.

A trench heating system permitted good distribution of heat under stored sweetpotatoes, whether heat was provided with an oil-fired furnace or electric strip heaters. Water added to the trenches maintained a high relative humidity.

Sweetpotatoes lost weight and volume consistently during 35 days at 85° F. with high relative humidity. During storage at 60° F. and high RH loss of weight continued but loss of volume practically ceased. As loss of weight exceeded loss of volume intercellular space increased and the roots became visibly pithy. Intercellular space varied among varieties from approximately 5 to 10 ml. per 100 ml. of root tissue at harvest and varied in its rate of increase during storage. Intercellular space varied less than ± 0.8 ml. per 100 ml. of root tissue for any one variety even though harvested at 3 dates and from 3 locations. (MQ 2-73)

3. Controlled Atmosphere Storage of Cauliflower. Naked and vented film-wrapped Texas-grown cauliflower was stored in controlled atmospheres for 5 weeks at 35° F. in atmospheres of 0.75, 2.5, 5, and 10% oxygen with 5, 10, and 20% CO₂ with each oxygen level; and 10 and 20% carbon dioxide levels corrected daily with air. Comparable samples were held in air. After 5 weeks' storage naked heads showed significantly more weight loss than the wrapped and wrapper leaves were slightly greener on the film-wrapped heads than on the naked heads in 0.75% oxygen, but not at higher oxygen levels. Appearance was maintained best at 0.75, 2.5, or 5% oxygen and in combination with zero, 5, or 10% carbon dioxide. These low oxygen atmospheres did not adversely affect either the uncooked or cooked product. However, the presence of carbon dioxide with 10% or higher oxygen was detrimental to quality. Tests will be continued.

Controlled laboratory tests in California verified results reported last year of injury to cauliflower commercially wrapped in unperforated films. Holding cauliflower at a higher temperature (41° F.) and for shorter periods (1 week) than in the Texas tests in 5, 10, or 15% CO₂ with 15, 10, and 5% O₂ respectively, resulted in an undesirable grey and soft curd when cooked. Appearance ratings were substantiated by reflectance and shear-press measurements. The effects of high CO₂ were not apparent on raw cauliflower and diminished after removal from the modified atmosphere. Low oxygen (1, 5, or 10%) had no adverse effect on color or texture of cauliflower in the absence of CO₂ during 7 days at 41°. However, some tasters noted an off-flavor in curds held in 1% oxygen. (MQ 2-71)

4. Symptoms of Freezing Injury. Symptoms of freezing injury of carrots after thawing included: blackening, watersoaking, cracking, and pitting. Blackening increased with the severity of the freezing, regardless of the thawing temperature. Pitting was more severe in carrots thawed at 70° F. than in those thawed

at 40° but lightly frozen carrots thawed with much less total damage at 70° than at 40°. Cracking and watersoaking were present only in carrots frozen 4 hours or more at 20° or below.

Peppers lightly frozen recovered with less damage at 40° than at 70° F. After being frozen 1/2 hour at 20°, 82% of the peppers held at 40° thawed with no visible damage. When thawed at 70°, only 50% recovered. When the peppers were frozen severely, the damage after thawing was about equal at both temperatures. Decay, watersoaking, shrivelling and pitting were freeze symptoms. (MQ 2-29)

D. Quality maintenance during transportation

1. Asparagus. Asparagus spears were held for 24 hours in 20 or 30% CO₂ plus 6 days in air at 36° or 41° F. to simulate transcontinental shipment. Soft rot of the cut ends after the period at low temperature and after 3 more days at 59° F. was significantly reduced by CO₂ treatment. Soft rot of the tip ends was not reduced by these treatments. When the CO₂ concentration was brought initially to 20% and reduced 1/2 every 15 or 30 hours during 7 days' holding, soft rot was reduced and overall quality was better than the controls held in air. An initial 30% concentration of CO₂ injured the spears. There was no impairment of flavor with either treatment. Spears with relatively open tips developed more soft rot than spears with tight tips although both tip conditions were in the range found commercially. Asparagus held 6 days at 40° remained in good condition when stored in air or in an atmosphere of 3% oxygen and 97% nitrogen. Off-flavors developed in 100% nitrogen. Respiration at 40° was about 30% lower in the low-oxygen atmospheres than in air but the reduced rate was not related to extended storage life. (MQ 2-13)

2. Lettuce. New Jersey lettuce held 4 weeks at 33° F. at 3 different modified atmospheres was in better condition, on removal, than lettuce held in air. When held an additional 3 days at 50° in air, only the lettuce held in 0% CO₂ and 1.8% O₂ remained better. The appearance of the lettuce from the atmospheres containing 3.5 to 7.0% CO₂ deteriorated rapidly because of a tan or bronze discoloration on all leaves.

California lettuce kept better in an atmosphere of zero CO₂ and 6% O₂ than in air, but 10% CO₂ and 10% O₂ was undesirable. After six weeks at 33° F. in the respective atmospheres, followed by 2 days at 45° in air, 88% of the lettuce held in zero CO₂ and 6% O₂ remained edible as compared to 32% edible in air whereas lettuce from 10% CO₂ and 10% O₂ was unusable because of the serious discoloration.

Temperatures in test shipments made in liquid nitrogen-refrigerated trailers averaged 3 to 5° F. warmer than those in trailers with mechanical refrigeration. Temperatures within the load in nitrogen trailers varied as much as 12° F. and were sometimes as high as 50° to 60° at destination. Oxygen levels in the nitrogen trailers were generally above 1% but in some test shipments, levels below 0.5% were found. In a few trailers CO₂ accumulated to more than 5%.

Less russet spotting generally developed in lettuce from the nitrogen trailers than in that from trailers with only mechanical refrigeration, but significant reductions were found only in lots having high susceptibility to this disorder. Decay was worse in lettuce from the nitrogen trailers than in that from the better refrigerated mechanical units.

Lettuce held without oxygen for 7 days at 36°, 41°, or 50° F. was severely injured; that held in 0.25% oxygen was moderately injured and had off-flavors; that held in 0.5% oxygen was occasionally injured; but lettuce held in 1% or 2% oxygen was not injured. Less pink rib and butt discoloration occurred in lettuce held in 1% or 2% oxygen at 36° or 41°. Russet spotting was reduced from 30% (in air) to 5% when susceptible lots were held in 1% or 2% oxygen. (MQ 2-71 and MQ 2-84)

E. Postharvest physiology

1. Treatment of Asparagus with a Growth Retardant. Dipping the basal ends of freshly harvested asparagus spears for 1 hour in 1000 or 2000 ppm of dimethyl-aminosuccinamic acid (Alar) reduced respiration 10 to 15 percent below that of non-treated asparagus. However this growth retardant had no apparent effect on weight loss, spear elongation, green color or decay after 3 or 5 days at 70° F. (MQ 2-61)

F. Postharvest disease control

1. Onions. About one hour after the necks of freshly harvested onions were sprayed with a Botrytis allii spore suspension, they were dusted with various dessicants and fungicides to seal the wounded necks from infection by neck rot. After 4 months in common storage, decay was reduced from 100% in the inoculated untreated lot to 45% in the inoculated Botran- and Calcium chloride-treated lots; and from 5% to about 3% in the non-inoculated lots. The other 14 treatments were less effective. In other tests, freshly harvested and topped onions flamed at the cut region were inoculated with either Botrytis allii spore suspensions, or by dusting with soil from a farm with a history of Botrytis neck rot. After 4 months in common storage flaming resulted only in a slight reduction of decay on some of the lots treated with Botrytis suspensions. When onions infected with soil borne Botrytis were subjected to flaming, the non-flamed lots averaged about 9 percent decay, the flamed lots 3 percent. (MQ 2-95)

2. Soft Rot in Bell Peppers. Peppers from two South Texas fields showed differences in susceptibility to bacterial soft rot after passage through a contaminated brush-waxer unit; and the degree of decay control obtained with hot water (128° F. for 1.5 minutes) after artificial inoculation. Pod stems with the highest dry weight developed the least infections and responded best to decay control treatment. The main source of soft rot infection in the packing shed was the brush-waxer unit. The development of soft rot was more than four times greater in peppers collected after passage through the brush-waxer than in peppers collected before. Contamination of the brush-waxer with

soft rot inoculum was largely responsible rather than the wax itself. Spraying the waxer with strong chlorine solution did not always eliminate the inoculum.

Botrytis spores which were brushed on wound-free areas of pepper pods germinated in 4 days at 55° F. with high RH and caused death in small areas of surface tissue producing a speckled appearance on the pod. Generally, the germinating spores did not penetrate the epidermis, but the spores remained alive for 2 or 3 weeks on the surface. The adverse effect of chilling was demonstrated by holding pods at 32° F. for 0, 4, 8, 12, 16, and 20 days and inoculating with gray mold just before they were shifted to 55°. After 14 days at 55° the decay increased with each increase in the prior period at 32°. The results showed that high relative humidity and low temperature injury are the dominant factors in the predisposition of peppers to natural infection by Botrytis cinerea, the cause of gray mold of peppers. This project has been completed and a manuscript is under preparation. (MQ 2-87 and MQ 2-52)

3. Sweetpotatoes. Treatments with hot water, sodium-o-phenylphenate (SOPP) or 2,6 dichloro-4-nitroaniline (Botran) failed to control decay of sweetpotatoes damaged by wet soil. Control of soft rot (Rhizopus sp.) and charcoal rot (Sclerotium bataticola) was obtained in normal roots with either chemical but surface and end rots (Fusarium sp.) were not controlled.

Polymethylgalacturonase and macerating enzyme activity can be demonstrated in the juices obtained from autoclaved sweetpotatoes upon which Rhizopus stolonifer has grown but no pectinmethylesterase (PME) activity can be detected. In the juices obtained from salt extracted frozen and thawed sweetpotatoes, only PME activity is detectable. The juices expressed from Rhizopus-rotted sweetpotatoes contain all three enzymes. The evidence suggests that PME is produced by the host and not, as is reported in the literature, by the pathogen. (MQ 2-73 and MQ 2-60)

4. Tomatoes. Mature-green tomatoes of Manapal variety were found to be more susceptible to postharvest decay by Alternaria tenuis than tomatoes of the W. R. Grothen Globe variety. Tomatoes of the Manapal variety were affected more by chilling, either while on the vine or after harvest, than Grothen Globe.

A disorder, in increasing amounts, has been noted on California and Mexican cherry tomatoes. The disease is characterized by a superficial stain, often seen in fine lines that radiate along sides of fruits. Isolations have yielded principally Alternaria, Stemphyllium and occasionally Cladosporium spp. (MQ 2-88 and MQ 2-64)

5. Lettuce. Lettuce held in 1 ppm of ozone for 3 days at 36° F. and high relative humidity was severely injured. The distal portions of the outer leaves were flaccid, water-soaked, and transparent. The exposed midribs showed rusty-brown flecks. The normal green color of the chlorophyll-containing tissue was changed to a pale yellow.

Lettuce affected by "speckles" (a field virus disorder) was inferior in appearance to normal lettuce after 7 days at 41° F. and after 4 additional days at 50°. At the second examination russet spotting, pink rib, decay and total defects were more prevalent in the virus infected than in the apparently healthy lettuce.

A fungal decay of head lettuce by an *Alternaria* species was found in a rail shipment from Arizona. The decay, frequently associated with bacterial soft rot, was also noted in some test shipments of western lettuce. Pathogenicity studies indicated the fungus is a weak pathogen whose virulence on lettuce appears dependent on a saprophytic start in dead tissue. (MQ 2-102 and MQ 2-64)

6. Cantaloupes. A soft, watery, stem-end decay of California and Mexican cantaloupes caused by the fungus, *Geotrichum candidum*, was noted on the New York market during the past year. Decay incidences of 1 to 16 percent were found in a few rail shipments on arrival. An isolated case of the decay on a honeydew melon from California was also found. There appears to be no previous record of its occurrence on the market. (MQ 2-64)

7. Effects of Chlorine on a Vegetable Decay Organism. Exposure time had a greater influence than temperature or pH on the activity of chlorine against *Alternaria tenuis* spores. Even at 36° F. and pH 8, an effective kill was obtained when the spores were exposed to 5 ppm chlorine for 30 minutes. Raising temperature from 50° to 68° increased spore kill, but a rise from 36° to 50° had little effect. A greater spore kill was obtained with 3 ppm chlorine at pH 6, 7, or 7.5 than with 5 ppm chlorine at pH 8. (MQ 2-116)

8. Effects of Modified Atmospheres on Growth of the Soft Rot Bacterium. The soft rot bacterium, *Erwinia carotovora* grew faster at 59° F. when carbon dioxide (5, 10, or 15%) was used in combination with a 0.5% oxygen concentration than when the low oxygen was used without CO₂. When the bacterium was incubated for 24 hours in air at 59°, differences in growth due to prior exposure to controlled atmospheres disappeared. (MQ 2-112)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Handling and Packaging

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- Kushman, L. J. and M. W. Hoover. 1965. The influence of chilling temperature upon acidity of Goldrush sweetpotato roots and flakes made from them. (Abstr.) Proc. Assoc. Southern Agr. Workers Inc. 62:188-189. (MQ 2-73)
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- Kushman, L. J., M. T. Deonier, and W. S. Anderson. 1964. Cooperative testing of varieties and cultural methods in twenty years of Cooperative Potato Research 1939-1959. Pages 16-18. Publ. by National Sweet Potato Collaborators. (MQ 2-73)
- Kushman, L. J. and D. T. Pope. 1965. Preliminary report of the estimation of intercellular space in sweetpotato roots and its relation to pithiness and specific gravity. (Abstr.) Proc. Assoc. Southern Agr. Workers Inc. 62:189. (MQ 2-73)

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- Stewart, J. K. and M. J. Ceponis. 1964. Transit temperatures of heavy loads of California lettuce shipped in several types of rail equipment. U. S. Dept. Agr. Mktg. Res. Rept. 683. (MQ 2-84)
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- Parsons, C. S., J. E. Gates, and D. H. Spalding. 1964. Quality of some fruits and vegetables after holding in nitrogen atmospheres. Proc. Amer. Soc. Hort. Sci. 84:549-556. (MQ 2-71)

Postharvest Disease Control

Kushman, L. J., W. R. Wright, J. Kaufman and R. E. Hardenburg. 1965.
Fungicidal treatments and shipping practices for controlling decay of
sweetpotatoes during marketing. U. S. Dept. Agr. Mktg. Res. Rept. 698.
(MQ 2-73)

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AREA 13

INSECT CONTROL IN MARKETING CHANNELS - CROSS COMMODITY

Problem. There are over 100 kinds of insects, 15 or 20 extremely abundant and widespread, that attack agricultural commodities after harvest, in storage, during processing and transportation, and in wholesale and retail marketing distribution. They cause an annual loss of up to one billion dollars through feeding damage or by contamination that reduces quality and value of products. There is need for applied research to develop more effective, economical preventive and control measures that are safe and do not leave objectionable pesticide residues. There is also need for extensive basic research to provide a sound foundation for conducting applied studies, and to provide leads for developing new approaches to prevention and control.

USDA PROGRAM

The Department has a continuing program headquartered at Savannah, Georgia, involving basic and applied research in entomology, biochemistry, and analytical chemistry, directed toward the solution of problems of insect infestation, damage, and contamination of agricultural commodities and their manufactured or processed products in the marketing channels. The research is conducted in cooperation with the Entomology Research Division, the Field Crops and Animal Products Research Branch of the Market Quality Research Division, the Commodity Credit Corporation, the Armed Forces Pest Control Board, the United States Public Health Service, the Food and Drug Administration, and a number of individual firms and trade associations in the chemical, packaging, paper, synthetic film, food processing, and milling industries. Contributed or transferred funds to assist in the program were received from the Department of Defense, the Atomic Energy Commission, and the Commodity Credit Corporation.

The AEC awarded a contract to Vitro Engineering Company for construction at Savannah, Georgia, of a gamma irradiation facility capable of irradiating flowing bulk grain or packaged foods. The facility is being made available to USDA for use in its research program. The unit will be operational by the middle of next reporting year.

A great deal of the program is conducted extramurally, supported by contract, grant, and PL 480 funds, and distributed in the several areas of research as follows:

A. Nonpesticidal control methods

A grant to the Institute of Plant Protection, Poznan, Poland, is for the study of the insect pathogen, Bacillus thuringiensis, as a possible control measure against certain moths that attack stored products. It became effective in 1962, continues to May 1967, and involves PL 480 funds with a \$17,075 equivalent in Polish zlotys.

A contract with the Stanford Research Institute, Palo Alto, California, is to identify and synthesize the natural attractants in certain dermestid beetles. It became effective in June 1965, continues through June 1967, and is in the amount of \$49,190.

A contract with the Midwest Research Institute, Kansas City, Missouri, is to develop effective insect repellents for protecting agricultural commodities and packaged products. It became effective in June 1965, continues through December 1967, and is in the amount of \$49,952.

B. Biology, ecology, and physiology

A grant to the University of California at Berkeley is for studies on the host finding behavior and parasitization performance by a hymenopterous parasite of a moth species that attack agricultural products. It became effective in June 1965, continues through June 1968, and is in the amount of \$15,017.

A grant to Clemson University in South Carolina is for research on the bio-nomics of the Indian-meal moth. It became effective in June 1965, continues through June 1967, and is in the amount of \$38,600.

A grant to the University of Georgia is for research on the effects of gamma irradiation on the physiology and reproductive potential of mites that attack stored products. It became effective in June 1965, continues through June 1967, and is in the amount of \$38,500.

A grant to the University of Georgia is to investigate the existence and origin of a sex attractant pheromone in the Indian-meal moth, and to evaluate the physical and chemical properties of the pheromone. It became effective in June 1965, continues through June 1967, and is in the amount of \$36,000.

A grant to the University of Georgia is for research on the effects of various frequencies and intensities of sound waves on the behavior and physiology of the Indian-meal moth. It became effective in June 1965, continues through June 1967, and is in the amount of \$34,550.

A grant to the Iowa State University is for research on low temperature adaptation and chill coma in stored-product insects. It became effective in June 1965, continues through June 1968, and is in the amount of \$56,508.

A grant to the Central College of Agriculture, Warsaw, Poland, is for a study of the nutritional requirements of mites that attack agricultural products. It became effective in 1961, continues to February 1966, and involves PL 480 funds with a \$10,732 equivalent in Polish zlotys.

C. Mode of insecticide action and development of resistance

A grant to the Iowa State University is for research on changes in activities of oxidative detoxication enzymes as related to age and growth stage of stored-product insects. It became effective in June 1965, continues through June 1968, and is in the amount of \$62,384.

D. Improved pesticidal control

A contract with the Vacudyne Corporation, Chicago, Heights, Illinois, is for designing, constructing, and installing an experimental fumigation chamber with controlled temperature, relative humidity, and pressure or vacuum. It became effective in June 1965, continues through September 1966, and is in the amount of \$74,106.

E. Insect-resistant packaging

A contract with the Battelle Memorial Institute, Columbus, Ohio, is to develop practical formulations and methods of application to paper that will prevent migration of insecticides or repellents from packaging components to products in the containers. The contract became effective in June 1965, continues through September 1966, and is in the amount of \$50,600.

F. Simplified pesticide residue analytical methods

A contract with the Midwest Research Institute, Kansas City, Missouri, is to develop rapid spot test methods for the qualitative detection of the major classes of pesticides on the major food commodities. It became effective in June 1965, continues through December 1966, and is in the amount of \$69,097.

G. Fate and effects of pesticide residues

A grant to the University of Helsinki in Finland is for research on the effects of pesticides on the storage life, chemical composition, food quality, and nutritive value of plant commodities. It became effective in December 1964, continues through December 1969, and involves PL 480 funds with a \$96,441.25 equivalent in new Finnish finnmaks.

The Federal scientific effort in this program totals 15.1 professional man-years divided as follows: 3.3 on nonpesticidal control methods; 1.4 on biology, ecology, and physiology; 1 on resistance studies; 2 on improved

pesticide control methods; 2.3 on insect-resistant packaging; and 5.1 on pesticide residues.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The States have an effective research program in insect control on commodities in marketing channels. Principal emphasis is on stored-grain insects. Fundamental studies are in progress on the genetics, biology, ecology, and physiology of these pests. Life history studies are performed to determine the effects of environmental factors such as temperature, grain moisture, type of food, and influence of crowding on population development, behavior, and diapause. The mechanism by which these insects orient to food is also under investigation.

Relationships between storage fungi and stored grain pests are being studied to determine the contribution insects make to losses caused by molds. Research is under way to establish the extent to which molds are disseminated and used as food by the insects. Various methods, including x-ray and microscopic examination of grains, are being used to determine the extent, time and place of occurrence of insect contamination. Harvesting methods and cleaning and storage facilities are being evaluated and the factors associated with the presence of contamination in different ecological situations are being determined.

Conventional chemical control studies involve the use of fumigants, protectants, and surface treatments. These materials are evaluated for their effectiveness in insect control, influence on seed germination and amount of residue remaining after use under various moisture and temperature conditions. Application methods are tested to determine the most efficient method of administration in different types of storage facilities.

Cultural control methods, including sanitation and aeration, also are under investigation. The influences of dockage, cleaning, insect movement, and other factors on these practices are being considered.

Natural resistance to stored-product insects in various types of grains is being evaluated and isolated for use in breeding programs to develop resistant varieties.

Investigations are also in progress on sex attractants, and the effects of high-frequency electric fields and ionizing radiation for control of stored-product insects.

Research is being performed by the States on chemical and insect contamination of market crops, particularly processing tomatoes. Emphasis is placed on finding ways of eliminating insect contaminants and chemical residues in the field before harvest or in the processing plant. Various chemicals in different formulations are being evaluated for their effectiveness and residual properties.

A total of 21.4 professional man-years annually is devoted by the States to research on insect control in marketing channels.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nonpesticidal control methods

1. Light. Flat grain beetles and merchant grain beetles gave the greatest positive response to high intensity ultraviolet light and black carpet beetles the greatest to low intensity. Cigarette beetles gave little response to any intensity and carpet beetle larvae responded negatively to the high intensity. Flat grain beetles did not respond at all to green light. Mediterranean flour moths and red flour beetles were the only species with a greater response to green than to ultraviolet light. When similar light traps were placed in a small space, a horizontal trap captured twice as many Indian-meal moths as did a vertical trap. The almond moth was the predominant species captured in preliminary tests with ultraviolet and green electroluminescent light traps in peanut storage warehouses. This indicates the species may be a more important pest of peanuts than has been realized. (MQ 1-12)

2. Sound. When insects were exposed for 4 days during their oviposition period to sound waves of 120 to 2,000 c.p.s. with less than 5 milliwatts output, from 2 speakers, the number of progeny was reduced 86 percent in the confused flour beetle, 60 percent in the Angoumois grain moth, and 47 percent in the almond moth. Exposure to a constant 120 c.p.s. had little effect. Exposure to 1, 12, or 16 kilocycles from a single speaker with the sound signal going on and off at 10-second intervals had little effect in reducing progeny of confused flour beetles or Indian-meal moths.

3. Gamma Irradiation. Egg, larval, hypopial, and adult stages of the grain mite (*Acarus siro*) were treated with 13,200, 17,500, 25,000, 45,000, and 100,000 rads of gamma irradiation. No dosage used was sufficiently high to produce immediate, complete mortality of the mites. Of the stages treated, the adults were the most tolerant, followed by the hypopi, eggs, and the larvae. Completion of the F₂ generation from treated adults occurred at the 25,000-rad dosage, but not at higher levels.

All metamorphic stages of the Indian-meal moth and the Angoumois grain moth were treated at the same dosage level as was used on the grain mite. Larvae of the Angoumois grain moth were controlled by all dosages except 13,200 rads, which permitted some larvae to develop to the adult stage and to effect some successful reproduction. The length of life of treated adults, and of adults treated as pupae, was not greatly shortened by the treatment, but the incidence of sterility and a marked reduction in progeny varied directly with the dosage used. Genetic damage, as evidenced by reduced reproduction, was transmitted to the F_1 generation. When treated directly, males of both species were less subject than females to genetic damage; however, the progeny of treated males evidenced more genetic damage than did those of treated females.

All stages of two species of Dermestidae, Trogoderma glabrum (Herbst.) and Attagenus piceus (Olivier), were treated at the same dosage levels as the mites. In addition, a fractionated treatment consisting of 13,200 rads repeated five times at hourly intervals for a total dosage of 66,000 rads was included. Eggs and larvae of both species were effectively controlled by all dosages. No dosage used was sufficiently high to produce immediate, complete mortality of either species. Reproduction by both species in the F_1 generation occurred only with the 13,200-rads dosage. Treated males of both species were less subject to genetic damage than were females. Genetic damage was transmitted to the F_1 generation of T. glabrum. (MQ 1-12)

4. Biological Control. Most of the previous experiments with Bacillus thuringiensis were done with E 58, a French product. During the past year, six new bacterial preparations coming from USA, Russia, France, and Germany were tested. Tests using young larvae of the Mediterranean flour moth showed that Plantibac, Biospor, and Bakthane were the most effective of the six preparations. With 2-day exposures to the bacterial preparations, young larvae were more susceptible than older larvae, but when longer exposures were made (14-21 days), there was no difference in susceptibility. The effectiveness of the bacterial preparations under different relative humidities varied greatly. Some, especially Bakthane, were more effective at high RH. Usually the greatest effectiveness occurred when initial exposure of the larvae to the bacteria was at low RH (17-30%) and the insects then transferred to a high RH (94%). It is believed some of the differences in effectiveness of the various preparations may result from the presence of thermostabile toxins in addition to B. thuringiensis. Tests are in progress to determine this. (E21-AMS-4(a)).

B. Biology, ecology, and physiology

1. Photoperiod Studies on the Indian-meal Moth. A rhythmic cycle of emergence of adults occurred when this species was reared at 27° C. with alternating 12-hour periods of light and dark. Emergence began at the onset of light provided by fluorescent bulbs, reached a peak just before the end of the light period, and ceased during the second half of the dark period. Insects reared in continuous light showed no rhythm of development or emergence. Developmental time

from egg to adult under alternating light and dark was only 19 days, as opposed to 34 to 40 days reported for the same temperature by other investigators. (Exploratory)

2. Almond Moth Mutant. A white-eyed mutation was discovered in a culture of almond moths reared for several generations. The character appears to be recessive. This strain may prove useful in special studies requiring marked specimens. (MQ 1-23)

3. Nutritional Requirements of Mites. During the year, 74 artificial diets based on the "Davis formula" were investigated. Some diets contained various antimicrobial agents and antibiotics. Arginine HCl greatly inhibited development of Tyrophagus infestans, but only slight inhibition resulted when diets were deficient in alanine and asparagin acid. None of the metallic salts tested had distinct effects on development of T. infestans, but salt-deficient diets caused high mortality of Acarus siro. Addition of potassium sorbate, sorbic acid, or calcium propionate to the "Davis formula" reduced survival and fecundity. Potassium nitrate did not affect development, fecundity or longevity of A. siro. The addition of high quantities (500 to 10,000 p.p.m.) of nystatin or novobiocin caused slight mortality during development. On a diet deficient of sterols, larvae and adults of both A. siro and Carpoglyphus lactis maintained high glycogen content, indicating an unexpected metabolic pattern. This suggests need for research on the lipid biochemistry of these species. Histological studies revealed no symbiotic fungi or bacteria in the alimentary canal or other internal organs of any of the mites examined that could provide nourishment in addition to that provided by the experimental diets being administered. (E21-AMS-1(a))

C. Mode of insecticide action and development of resistance

1. Resistance to Malathion. A strain of red flour beetles reared from insects collected in a peanut storage warehouse in which malathion had been used 3 years required 24 times as much malathion to produce 95-percent mortality as was required for equal mortality in a laboratory strain of this species. Laboratory tests with several strains of the almond moth represented by 14 collections from peanut storage warehouses showed that from 2 to 6 times more malathion was required to produce the same level of mortality as in the standard laboratory strain. Present data suggest tolerance to malathion rather than acquired resistance. A new technique for differentiating between male and female larvae of the almond moth made it possible to conduct tests showing that both sexes of the larvae had the same level of susceptibility to malathion. Methyl parathion, American Cyanamid 47300, and fenthion are three pesticides out of 12 tested that were more effective than malathion in laboratory tests against malathion-resistant red flour beetles. (MQ 1-23)

D. Improved pesticidal control

1. Preliminary Evaluation. Of 39 compounds evaluated for contact, residual, and vapor toxicity, 22 were sufficiently effective in one or more of these actions to warrant further testing for potential use against stored-product insects. Of 8 compounds tested by topical application to Indian-meal moth larvae, 4 were sufficiently effective to warrant further evaluation. (MQ 1-23)

Preliminary laboratory fumigation tests with 5 new compounds and mixtures showed two of them, n-butyl isothiocyanate and zinophos, to be more effective than the methyl bromide standard against 3 species of insects. Three new fumigant mixtures were tested against carbon tetrachloride as a standard and were less effective against confused flour beetles but more effective against black carpet beetle larvae. Two of the 3 were more effective against the cigarette beetle. Crotyl bromide tested in the laboratory in columns of wheat was more toxic than carbon tetrachloride against adult rice weevils after exposures of 12, 24, and 48 hours and at depths of 1, 12, 24, and 36 inches in the wheat.

(MQ 1-28)

2. Application Equipment and Methods. Performance evaluation of the dichlorvos vapor dispenser developed by researchers on this project showed that initial output from a 33-pound lot of 20-percent dichlorvos pellets was about 75, 150, and 300 grams of dichlorvos in 6 hours at 100°, 120° and 140° F., respectively. At 140° F. output decreased rapidly, but at 120° and 100° F. the decrease was relatively slow. Weekly applications of dichlorvos vapor for 5 months prevented insects from spreading from infested to adjacent uninfested stacks of flour in multiwall paper bags. The treatments also suppressed the number of insects moving from infested to uninfested bags within the same stack.

(MQ 1-24)

E. Insect-resistant packaging

1. Evaluation of Repellents. Preliminary evaluation of 92 compounds revealed 8 that were more repellent than the synergized-pyrethrum standard. (MQ 1-20)

2. Residue Barriers. Saran-coated kraft paper liners prevented migration of piperonyl butoxide from the outer layer of small, 2-ply bags into flour within the bags during a 12-month storage test. Flour in bags with only natural kraft paper liners contained 24 to 30 p.p.m. of piperonyl butoxide. Saran film, saran-coated kraft, or polyvinyl acetate-coated kraft prevented or greatly reduced the migration of methoxychlor from a coated sheet of paper into flour.

(MQ 1-1 (Rev.))

3. Shipping and Storage Tests. Storage tests showed that small bags coated with dimethrin at 50 and 100 mg./sq. ft. gave resistance to insect penetration about equal to the standard of pyrethrins and piperonyl butoxide at 5 and 50 mg./sq. ft. Dimethrin and piperonyl butoxide, each at 50 mg./sq. ft., was slightly less effective.

(MQ 1-21)

A large-scale shipping and storage test was to compare the effectiveness of insect-resistant multiwall paper bags against standard cotton bags in preventing insect infestation of cornmeal while en route from the corn mill in the U. S. to distribution points in Brazil. The paper bags include two kinds of closure: (1) Tape-over-stitch and (2) pasted, both using new heat-activated adhesives. Inspection of the bags at Mobile, Alabama, after arrival from Illinois and brief storage at the port showed that some of the cotton bags were already infested. They required fumigation before loading aboard ship for Brazil. None of the paper bags examined were found to be infested. Completion of the test involves inspection of bags upon arrival in Brazil and after 6 months' storage there.

A large-scale performance evaluation of insect-resistant multiwall paper bags is in progress, comparing the bags against present standard military package specifications. The test bags include two kinds of closure: (1) Tape-over-stitch and (2) pasted, both using new heat-activated adhesives. The test includes three phases: (1) Transit from flour mill to military storage depot, (2) storage at the depots, and (3) storage aboard ships. The insect-resistant bags gave complete protection against infestation during the first phase. The other two phases are still in progress. (MQ 1-17)

In studies directed toward developing cotton bags that are insect-resistant, bags of cotton sheeting treated with pyrethrins and piperonyl butoxide, with and without saran liners, were still protecting cornmeal against insect infestation after the first 6 months of storage under simulated warehouse conditions, with constant exposure to several species of insects. Saran liners in untreated bags also kept the cornmeal insect-free for 6 months. After 6 months the cornmeal in the treated bags with no liner contained 30 to 35 p.p.m. of piperonyl butoxide, while the meal in the bags with the saran liners contained no detectable residue. (MQ 1-36)

4. Physical Resistance of Packages to Insect Invasion and Penetration. After 12 months of exposure to insect infestation, 2 out of 9 1-mil and 8 out of 9 2-mil polycarbonate bags were still free of insect penetrations. None of the bags made of heavier polycarbonate film were penetrated. During the same exposure period all 9 bags of 3-mil polyethylene, 5 out of 9 of 5-mil, and all 9 kraft paper bags were penetrated. Based on resistance to insect invasion, 3 out of 13 pressure-sensitive tapes appeared promising for use in tape-over-stitching closures for multiwall paper bags. A new resealable closure for plastic bags, known as "Zip-Lip," prevented insect invasion for 12 months and was not invaded within 3 months even after having been opened and reclosed as many as 25 times.

A large-scale test involving 60,000 pounds of dry milk was set up to investigate the resistance to insect invasion of multiwall bags purchased by ASCS under Type G specifications. After 1 month of exposure none of the 9 Type G bags inspected was invaded, while 6 of 9 Type E bags were invaded. After 3

months of exposure 3 of 9 Type G bags were invaded but only 1 insect was found in each of these bags. All 9 of the Type E bags were invaded and were heavily infested with insects. At neither inspection were bags having the Type G closure plus a synergized pyrethrins-treated outer ply invaded. (MQ 1-22)

F. Fate and effects of pesticide residues

1. Chemical Analyses. Residue analyses were made during the reporting period on 3055 samples involving 18 different products and 14 different insecticides. About one half of the manpower effort this year was devoted to refinement and modification of analytical methods to meet requirements of new research projects. The new methods now available are: bromides, dichlorvos, and cyanides in tobacco; DDT, aldrin, and dieldrin in wool; phosphine, carbon tetrachloride, ethylene dichloride, and bromides in wheat, wheat fractions, flour, and bread; and diazinon in peanuts and corn. (MQ 1-29)

2. Commodity Treatments. The PL 480 study in Finland on pesticide residues in agricultural commodities is reported in Area 3, Deciduous Fruits and Tree Nuts. (E8-AMS-1(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Nonpesticidal Control Measures

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Tilton, E. W., W. E. Burkholder, and R. R. Cogburn. 1965. The effects of confining confused flour beetles in gelatin capsules prior to, during, and following gamma irradiation. Jour. Econ. Ent. 58(1): 175-176. (MQ 1-12)

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Biology, Ecology, and Physiology

Boczek, Jan. 1964. Artificial medium for rearing some stored product mites. Acarologia 6: 392-398. (E21-AMS-1(a))

Safe Pesticidal Control Measures

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Insect-Resistant Packaging

Highland, H. A., and Edward G. Jay. 1965. An insect-resistant film. Modern Packaging 38(7): 205-206, 282. (MQ 1-22)

General

Henderson, L. S. 1965. The status of stored-product insect research in the U. S. Department of Agriculture. Proc. XII Int. Congr. Ent., London, 1964 (1965), p. 660. (MQ 1)

AREA 14

INSTRUMENTATION FOR OBJECTIVE MEASUREMENT OF MARKET QUALITY

Problem. Agricultural commodities vary widely in many of the factors that determine market quality. A continuing need exists for more and better instruments for use in the marketing of agricultural commodities, including instruments to measure color, moisture content, texture, maturity, composition, and to detect defects in a wide range of commodities. Inspection and grading services, food handlers and processors, and research workers in the broad field of agricultural marketing could make use of instruments of this kind. The development of techniques of measurement suitable for use in automatic sorting is included in this area. The rapid conversion to mechanical handling of agricultural commodities makes it imperative that automatic devices be developed to evaluate and control the quality of the product.

USDA PROGRAM

The Department has a continuing program involving engineers and physicists engaged in the broad field of instrumentation, procedures and methods for use in basic and applied research on market quality of agricultural products. This work supplements other marketing research through superior instrumentation designed for the specific problem under study, and is cooperative with other units of the Division.

The federal scientific effort devoted to research in this area totals 4 professional man-years.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The State stations have a continuing program of research directed to developing objective measures of quality. The program deals with a number of agricultural commodities and products derived from food and fibrous crops.

While subjective judgments of quality by taste, odor, touch or appearance, using consumer panels, are too slow and costly to keep pace with modern production and marketing demands, nevertheless, they normally serve as the baseline for establishing the adequacy of objective methods. A considerable portion of the station research program dealing with objective measurements constitutes parts of studies which have other aims, such as identifying quality factors, measuring the effects of production practices on quality, or developing better methods for handling and storage of agricultural commodities.

Physicists at the Tennessee station are developing and improving instruments to rapidly and accurately measure standard cotton fiber properties, namely: fineness, strength, elongation and maturity for use by textile mill operators and by cotton breeders. Cotton and wool textile performance properties continue to be evaluated by other physical instruments such as fadeometers and various abrasion meters.

Studies at the Massachusetts station are in progress designed for continuous on-stream color monitoring for processing of fruit juice products such as cranberry juice cocktail. Food scientists at many stations are studying objective methods of measuring texture, color, and flavor components in raw and processed products. The influence of processing treatments and storage stability on food quality is determined by a wide variety of optical and other light-measuring instruments. One investigation has been concerned with the non-destructive sampling and detection of water core defects in apples and the internal breakdown scores in such fruit. Another study subjects strawberries to a microscopic examination for cellular changes in structure related to texture and determines color quality with a Hunter color difference meter.

Other studies of vegetable quality seek to develop and standardize reliable objective methods for evaluating potato texture and apply them to research and production quality. Among the several regional marketing projects concerned with quality standards, that of the Northeastern area, NEM-30, entitled Quality Maintenance, Measurement and Control in the Marketing of Vegetables, illustrates the broad attack on this important technological area. Eight stations of the 12 in this region are conducting work to "develop objective methods for measuring quality, correlate these with market acceptance, and utilize these methods in developing grades and standards and quality control procedures." Work at one contributing station, for example, is progressing on the value of a simple punch test for rapidly determining the firmness of peas and cucumbers using an Instron universal testing machine. This speedy procedure gave excellent correlation with the much slower chemical analysis for alcohol-insoluble solids and could offer advantages for quality control of processing.

Measurements of applied force using shear presses, penetrometers, and viscosimeters have been studied for meats, cheese, jams, and jellies to determine their value in quality assessments by station investigators. New attachments to the shear press have been developed for better metering the tenderness-maturity factor of raw vegetables. Gas chromatography has been increasingly applied in many investigations seeking to measure critical chemical components of foods and other agricultural commodities. The New Jersey station has developed chemical methods, for example, to determine the concentration of new coccidiostatic drugs added to animal feeds. Fluorimetry can now replace microbiological assay methods for speedily and accurately determining certain antibiotics in feeds.

Considerable effort is devoted to study reliable objective methods for measuring carcass traits which may be correlated with quality and quantity of beef and lamb. Principles of ultrasonic energy have been used for this purpose to differentiate fat from lean meat in the living animal. Other physical and chemical measurements are employed for obtaining over-all product quality.

A total of about 19.3 professional man-years is devoted by the States to research on instrumentation for objective measurement of market quality.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Moisture Measurement. Work was initiated on the development of a rapid method for determining the variability in moisture content within a sample of corn. Methods showing the greatest promise are the use of a capacitance measurement or an electrical resistance measurement on individual kernels. A Tag-Hepenstal Moisture Meter was modified for making both types of measurements. Results were encouraging and, except for difficulty with kernels damaged by heat, it appears the modified Tag-Hepenstal Moisture Meter can be used. Effort is now being devoted to automating the measurement for convenient handling of the sample and easy readout of moisture distribution.

2. Fruit and Vegetable Quality Measurements.

(a) Apples. A contract was negotiated to develop equipment using light transmittance techniques for sorting apples for maturity and water core. The contract calls for a unit which will orient the apples, measure the light transmitted through the fruit at four wavelengths, and from this information compute an index of maturity and an index of water core. The apples are to be sorted into four categories at the net rate of three per second. It is anticipated the unit will be available for test in the harvest season of 1967.

Tests to determine the effect of position on the maturity and water core measurements indicated that, while an apple is being measured, the main axis of the apple and the optical axis of the instrument should coincide and be within 10° of each other.

Work on detecting internal browning in apples indicated that the four-filter difference meter gave improved results in detecting low levels of browning because the chlorophyll content of the fruit could be evaluated at the same time that the browning measurement is made. The results indicated that the dividing line between sound fruit and apples with internal browning changed with time as the apples ripened in storage. The main factors which appeared to be useful in predicting which apples would develop internal browning were maturity and water core. These factors can be evaluated at harvest time.

An index of scald was developed for use in evaluating low levels of scald on Red Delicious apples. This index is the ratio of two reflectance measurements, or $\frac{R_{730 \text{ nm}}}{R_{800 \text{ nm}}}$. A similar index of color was developed for Red Delicious apples; i.e., $\frac{R_{620 \text{ nm}}}{R_{670 \text{ nm}}}$.

Preliminary exploration of the use of sonic energy to indicate quality characteristics of apples has shown promise. Equipment has been obtained for inducing sonic vibrations in apples and measuring the magnitude of these vibrations as a function of frequency. The frequency range from 20 to 2000 cps is scanned and the amplitude of vibrations recorded as a continuous curve. Obvious differences in the recorded curves were obtained for hard and soft apples, but reproducible measurements were difficult. Improved methods of coupling the sonic energy to the sample must be developed before a useful analysis can be made. A research contract has been negotiated with an industrial firm to develop techniques for making sonic measurements. This contract should provide the needed background information.

(b) Blueberries. A test was carried out to correlate light transmittance measurements with the concentration of extracted anthocyanin pigment. Analysis of the data has not been completed at the close of this reporting period.

(c) Miscellaneous. An annotated bibliography of the optical properties of agricultural products has been prepared. This bibliography lists references containing data on reflectance transmittance, fluorescence, phosphorescence, and index of refraction of unprocessed agricultural products.

3. New Instruments.

(a) Reflectance Attachment. An attachment, employing fiber optics, for making reflectance measurements was developed to be used with the light transmittance difference meter. The unit was tested by measuring the color of red apples; i.e., $\frac{R_{620 \text{ nm}}}{R_{670 \text{ nm}}}$, and correlating with the same measurement made on the Bausch and Lomb Spectronic 505. A correlation coefficient of 0.997 was obtained.

(b) Tristimulus Computer. An analog computer has been designed and built to calculate tristimulus color values when attached to a recording spectrophotometer. The computer calculates the tristimulus values by the weighted ordinate method summing the weighted reflectance values at ten-nanometer increments from 380 to 740 nanometers. An accuracy of ± 0.2 percent is obtained from the computer itself and an over-all accuracy of ± 0.5 percent can be obtained when coupled to a well-adjusted

spectrophotometer. This computer was designed for the Bausch and Lomb 505 Spectrophotometer, but it is readily adaptable to most recording spectrophotometers.

(c) Versatile Photometer. A simple wide range photometer circuit has been designed for use with multiplier phototubes. This circuit, which uses readily available, low-cost, operational amplifiers provides either a linear or a logarithmic response. A dynamic range of seven decades is obtained in the logarithmic mode, and the stability and noise are limited by the phototube rather than the photometer. The rise time is about one microsecond at high light levels permitting measurement of high-speed light changes. This photometer is being used as a general purpose unit in a wide range of experiments and has also been constructed into special purpose instruments.

B. Biophysics

1. Photoperiodism in plants. The rate of conversion of phytochrome from one form to the other has been measured in cooperation with Dr. Warren L. Butler, University of Pennsylvania; Dr. Henry Linschitz, Brandeis University; and Dr. H. W. Siegelman, Plant Physiology Laboratory, ARS. An instrumentation set-up at Brandeis University was used for some of the measurements and others were made with instruments constructed in our laboratory. Phytochrome was found to convert from P_{FR} to P_R in less than 100 microseconds and from P_R to P_{FR} in 1 second at 10°C . Evidence of two intermediates were found in the conversion from P_R to P_{FR} . The first intermediate had a peak absorption at 678 nm and a decay time of 0.01 sec.; the second intermediate had a peak absorption at 710 nm and a decay time longer than 0.1 second.

2. Photoperiodism in insects. Work has been initiated in cooperation with the Entomology Research Division to determine the pigment which controls diapause in insects. An experiment has been designed and equipment is now being built to determine the action spectrum for the radiant energy which controls initiation of diapause in the pink bollworm and the cotton bollworm. This action spectrum will be determined on larvae feeding on artificial media in a controlled chamber. Since the normal habitat for insect larvae is the inside of fruits and vegetables, the spectral transmittance properties of these must be considered. Therefore, the spectral transmittance properties of a number of fruits and vegetables have been measured for the spectral region from 380 to 1800 nm. Measurements have been made on samples having a wide maturity range and of different varieties. Samples include: apples, grapes, peaches, tomatoes, cucumbers, pecans, and cotton bolls. All samples show maximum transmittance in the 700- to 900-nm region, and low transmittance in the 400-nm region. The transmittance in the 400-nm region is so low that it appears very unlikely that insects can use this region for diapause control when inside a peach or a cotton boll. The transmittance in the 700- to 900-nm region appears adequate in all samples for this region to be used by the insects.

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AREA 15

PIONEERING RESEARCH - MARKET QUALITY

Problem. Fresh fruits and vegetables are living organisms that continue many vital processes after harvest. These processes involve biochemical and physiological changes and activities. Rate of ripening, aging and susceptibility to disease are factors greatly influencing the storage and marketing life and the quality of fruits and vegetables. Since fundamental processes in the plant tissues in a large measure govern these changes a continuing need exists for more basic information on postharvest physiology, including enzymatic activities, the biosynthesis and function of various natural occurring volatiles, reactions of mitochondria including the electron transport chain, the cytochromes, and other activities associated with respiration. This information should furnish a basis for a better understanding of the fundamental behavior of agricultural commodities, and result in improved quality in the products that reach the consumer.

USDA PROGRAM

The Department has a continuing program at Beltsville, Maryland, involving plant physiologists and chemists engaged in basic studies directed toward developing information on the physiological and biochemical changes that occur in fruits and vegetables and other plant material after harvest under conditions that may be encountered in transportation, storage and marketing. This work supplements and is cooperative with other marketing research in the Division.

The Federal scientific effort devoted to research in this area totals 3 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Postharvest Physiology

1. Mitochondria and Cytochromes. Work on the activities of mitochondria and cytochromes in plant tissues has been continued with mitochondria isolated from a white variety of sweetpotato. Low temperature (liquid nitrogen, -195.8°C) spectra of these mitochondrial suspensions indicate that three b-type cytochromes are present. Recently, one of the b-type cytochromes was isolated from sweetpotato mitochondria and partially characterized in respect to its chemical and physical properties. None of these cytochromes had been isolated previously from plant tissue.

2. Ethylene. The physiological importance of ethylene as a ripening agent for fruits and vegetables has been recognized for many years. However, the role of ethylene in fruit metabolism and aging, and in the earlier stages of growth and development has remained largely unknown. During the past year, the Pioneering Research Laboratory has found that methionine in apple tissues is a substrate for the formation of ethylene. A complete reaction system has been found for the degradation of methionine to ethylene. A reaction system has also been discovered in which peroxidated unsaturated fatty acids give rise to a number of hydrocarbon gases including ethylene. Both of these reactions are catalyzed by cuprous ions at room temperatures. The discovery of these reactions is an advance in the field of chemistry concerned with metal-catalyzed degradation reactions as well as a contribution to the understanding of the origin of ethylene in plant tissues.

Cooperative studies with the Horticultural Crops Branch have shown that ethylene production by Penicillium digitatum is greater with glucose as a carbon source than with sucrose, citrate, glycerol, pyruvate or malate. In the presence of the above carbon sources, the optimum pH for ethylene production of the culture gradually shifted with time from about pH₆ to pH₄. The finding that metabolic inhibitors fail to block ethylene production suggests that ethylene synthesis may proceed by several pathways.

3. Physiological Effects of Diuron on Dodder. In a cooperative study with the Crops Protection Research Branch and the Plant Physiology Pioneering Laboratory, it was found that treatment of dodder seedlings with 3-(3,4-dichlorophenyl)-1, 1-dimethylurea (diuron) blocks the oxygen evolution produced by photosynthesis. Neither onset of twining nor the number of coils produced about the host plant was affected by the treatment.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Postharvest Physiology.

- Baker, James E. 1964. The Repeating Unit of Plant Mitochondrial Membranes. Proc. Eastern Experiment Station Collaborators' Conference on Post-Harvest Physiology. pp. 6-7.
- Lieberman, Morris. 1964. Genesis and Biogenesis of Ethylene. Proc. Eastern Experiment Station Collaborators' Conference on Post-Harvest Physiology. pp. 19-20.
- Lieberman, Morris, Asen, Sam, and Mapson, L. W. 1964. Ethylene Oxide an Antagonist of Ethylene in Metabolism. Nature 204. pp. 756-758.
- Lieberman, Morris, and Mapson, L. W. 1964. Genesis and Biogenesis of Ethylene. Nature 204. pp. 343-345.
- Baker, James E., and Borchelt, Margaret. 1965. Partial Purification of a b-type Cytochrome from Sweet Potato Mitochondria. (Abstract). Proc. Annual Meetings, Am. Soc. Plant Physiologists. p. LV.
- Butler, W. L., and Baker, J. E. 1965. A Haemoprotein from Lipid of Peanuts. Nature 205. pp. 1319-1321.
- Lieberman, Morris, and Baker, James E. 1965. Respiratory Electron Transport. Ann. Rev. Plant Physiology 16. pp. 343-382.
- Lieberman, Morris, and Kunishi, A. T. 1965. Ethylene Production from Methionine. (Abstract). Proc. Annual Meetings, Am. Soc. Plant Physiologists. p. XIX.

Line Project Check List -- Reporting Period July 1, 1964 to June 30, 1965

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area and Subheading
MQ 1	Methods for the prevention and control of insects attacking agricultural products in the marketing channels	Hyattsville, Md.		
MQ 1-1(R)	Packaging insecticide formulation studies	Savannah, Ga.	Yes	13-E-2
MQ 1-6	Fumigation studies on cheese mites	Fresno, Calif.	Yes	2-B-2
MQ 1-7	Ecology of stored-tobacco insects	Richmond, Va.	Yes	11-A-2
MQ 1-9	Infrared rice dryers for insect control	Fresno, Calif.	Yes	4a-D-1
MQ 1-12	Physical energy for detecting and controlling insects	Savannah, Ga.	Yes	13-A-1,3
MQ 1-15	Laboratory evaluation of protectants for commodities	Manhattan, Kans.	Yes	3-G-1
		Fresno, Calif.		4-C-3
				4a-D-2
MQ 1-16	Forced-distribution fumigation of grain in commercial storages		No	
MQ 1-17	Storage tests of insect-resistant packages	Savannah, Ga.	Yes	13-E-3
MQ 1-18	Effects of air movement on stored-grain insects	Manhattan, Kans.	Yes	4-C-2
MQ 1-19	Protective treatments for rough rice		No	
MQ 1-20	Preliminary evaluations of compounds for insect resistant packages	Savannah, Ga.	Yes	13-E-1
MQ 1-21	Preliminary storage tests of insect resistant package treatments	Savannah, Ga.	Yes	13-E-3
MQ 1-22	Physical resistance of packages to insects	Savannah, Ga.	Yes	13-E-4
MQ 1-23	Preliminary evaluation of insecticides	Savannah, Ga.	Yes	13-B-2
				13-C-1
				13-D-1
MQ 1-24	Development of aerosol and mist spray formulations	Savannah, Ga.	Yes	13-D-2
MQ 1-25	Spray application studies for warehouses		No	
MQ 1-26	Laboratory evaluation of moth-proofing compounds	Savannah, Ga.	Yes	8-B-1
MQ 1-27	Intermediate evaluation of grain protectants (R)	Manhattan, Kans.	Yes	4-C-1
		Tifton, Ga.		6-C-1,2
MQ 1-28	Laboratory evaluation of fumigants for stored-product insects	Savannah, Ga.	Yes	13-D-1
MQ 1-29	Determination of chemical residues	Savannah, Ga.	Yes	8-B-2
				13-F-1
MQ 1-31	Preconditioning stored-product insects to fumigants	Manhattan, Kans.	Yes	4-C-2
MQ 1-32	Studies of natural attractants in dermestids (C)	Fresno, Calif.	Yes	2-B-1
MQ 1-33	Effects of fumigant residues on quality of tobacco	Richmond, Va.	Yes	11-A-4
MQ 1-34	Controlling insects in and around fruit processing plants	Fresno, Calif.	Yes	3-G-1
MQ 1-35	Toxic and repellent materials for cigarette beetles	Richmond, Va.	Yes	11-A-3
MQ 1-36	Development of insect-resistant cotton bags**	Savannah, Ga.	Yes	13-E-3
MQ 1-37	Flowing steam under vacuum to control tobacco insects**	Richmond, Va.	Yes	11-A-1
MQ 1-39	Protection of packaged food against pesticides** (C)		No	
MQ 1-40	Insect repellents for food packages and grain** (C)		No	
MQ 1-41	A fumigation and controlled environment chamber (G)		No	
MQ 1-42	Host finding and parasitization performance by a hymenopterous parasite** (GR)		No	
MQ 1-43	Oxidative detoxication enzymes of stored-product insects** (GR)		No	
	*Discontinued during reporting period			
	**Initiated during reporting period			

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Line Project Check List -- Reporting Period July 1, 1964 to June 30, 1965

Work & Line Project Number	Work and Line Project Titles	Work Locations	During Past Year	Line Proj. Incl. in Summary of Progress	Area and Subheading
MQ 2	Maintaining and improving agricultural product quality in storage, transportation, and handling				
	Program Leadership	Hyattsville, Md.			
MQ 2-7(R)	Control of deterioration of rough rice	College Sta., Tex.	Yes		4a-B-1
MQ 2-12	Storage of plums*		No		
MQ 2-13	Modified atmospheres, containers, transit services on asparagus*	Fresno, Calif.	Yes		12-D-1
MQ 2-15	Cut flowers and ornamentals*	Beltsville, Md.	Yes		11b-A-2,3
		Chicago, Ill.			11b-C-2
MQ 2-23	Maintaining quality of vine ripened tomatoes*		No		
MQ 2-24	Pre-harvest infection of citrus fruit and post-harvest decay*	Pomona, Calif.	Yes		1-E-1
MQ 2-29	Detection and description of freezing injury	Beltsville, Md.	Yes		12-C-4
MQ 2-31	Chemicals for control of sprouting*	Beltsville, Md.	Yes		9-C-3
		Presque Isle, Me.			
		E. Grand Forks, Minn.			
MQ 2-33 (R)	Packaging Eastern peaches and nectarines		No		
MQ 2-42	Loading methods and protective services for Maine potatoes	Presque Isle, Me.	Yes		9-D-2
MQ 2-44	Long term storage of vegetable oils*	Washington, D.C.	Yes		6-B-2
MQ 2-45	Modified atmospheres for berries		No		
MQ 2-52	Gray mold of peppers	Beltsville, Md.	Yes		12-F-2
MQ 2-53	Precooling and transporting Florida citrus fruits and vegetables	Orlando, Fla.	Yes		1-D-1
					3-D-2
MQ 2-55	Transit temperatures - California potatoes	Fresno, Calif.	Yes		9-D-1
MQ 2-56	Physiological breakdown in stored onions*		No		
MQ 2-57	Controlled atmospheres for Western apples*		No		
MQ 2-58	Market quality of Western lettuce*		No		
MQ 2-59	Market diseases of cucurbits*		No		
MQ 2-60	Host-parasite physiology of market diseases	Beltsville, Md.	Yes		1-E-6
					12-F-3
MQ 2-61	Antioxidants, metabolic inhibitors on vegetables	Beltsville, Md.	Yes		12-B-2
					12-E-1
MQ 2-62	Deterioration of grass seed	Beltsville, Md.	Yes		4b-B-1,2
MQ 2-63	Plastic film for Eastern fruit	Beltsville, Md.	Yes		3-B-1
					3-C-1
MQ 2-64	New market diseases	Chicago, Ill.	Yes		3-F-11
		Belle Mead, N.J.			11b-C
		Fresno, Calif.			12-F-4,5,6
MQ 2-65	Post-harvest diseases Florida citrus	Orlando, Fla.	Yes		1-B-1
		Pomona, Calif.			1-E-2
MQ 2-66 (C)	Control of pear scald	Corvallis, Ore.	Yes		3-E-3
MQ 2-67	Forecasting storage diseases of apples	Wenatchee, Wash.	Yes		3-F-1
MQ 2-69	Storage temperatures and processing quality of potatoes	E. Grand Forks, Minn.	Yes		9-C-1
MQ 2-70	Deterioration of grain in storage	Beltsville, Md.	Yes		4-B-1
MQ 2-71	High nitrogen or carbon dioxide in shipments of fruits and vegetables	Beltsville, Md.	Yes		9-C-4
		Fresno, Calif.			12-C-3
		Harlingen, Tex.			12-D-2
MQ 2-72	Lenticel spot of Golden Delicious apples	Wenatchee, Wash.	Yes		3-B-2
MQ 2-73	Reducing injury, decay, and shrinkage of sweet potatoes	Raleigh, N.C.	Yes		12-C-2
					12-F-3
MQ 2-74	Florida grapefruit on European markets		No		
MQ 2-75	Maintaining meat quality	Beltsville, Md.	Yes		5-B-1
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Line Project Check List -- Reporting Period July 1, 1964 to June 30, 1965

Work & Line			Line Project Incl. in
Project		Work Locations	Summary of Area and
Number	Work and Line Project Titles	During Past Year	Progress Subheading
MQ 2-76	:Cause and prevention of heat damage in rough rice		No
MQ 2-77	:Cause and prevention of damage and off color in rough rice		No
MQ 2-78	:Bruising of Red River Valley potatoes during handling into storage	:E. Grand Forks, Minn.	:Yes : 9-B-1
MQ 2-79	:Respiration and rind breakdown in citrus fruits	:Orlando, Fla.	:Yes : 1-C-1
MQ 2-80	:Vacuum cooling prepackaged vegetables		:No
MQ 2-81	:Quality retention of eviscerated poultry	:Beltsville, Md.	:Yes : 10-B-2
MQ 2-82	:Gamma radiation on market life of fruits and vegetables		:No
MQ 2-83	:Transit environments on Western strawberries	:Fresno, Calif.	:Yes : 3-D-1
			: 3-F-4
MQ 2-84	:Refrigeration of Western fruits and vegetables in mechanically refrigerated cars and trailers	:Fresno, Calif.	:Yes : 12-B-1
		:Belle Mead, N.J.	: 12-D-2
MQ 2-86	:Chilling injury of eggplant		:No
MQ 2-87	:Control of bacterial soft rot in bell peppers*	:Harlingen, Tex.	:Yes : 12-F-2
MQ 2-88	:Ripening of Florida grown tomatoes	:Orlando, Fla.	:Yes : 12-F-4
MQ 2-89	:Storage of asparagus crowns	:Beltsville, Md.	:Yes : 12-C-1
MQ 2-90	:Effects of heat treatments on potato diseases	:Presque Isle, Me.	:Yes : 9-E-2
MQ 2-91	:Apple and pear scald	:Beltsville, Md.	:Yes : 3-E-1
		:Wenatchee, Wash	:
MQ 2-92	:Ventilation rates and humidity of potatoes	:E. Grand Forks, Minn.	:Yes : 9-C-2
			:
MQ 2-93	:Prestorage and handling effects on Maine potatoes	:Presque Isle, Me.	:Yes : 9-B-2
			: 9-E-1
MQ 2-94	:Composition, maturity, and deterioration of blueberries	:Raleigh, N.C.	:Yes : 3-B-3
			:
MQ 2-95	:Decay of onions in storage	:Belle Mead, N.J.	:Yes : 12-F-1
MQ 2-96	:Radiation and pathogenicity of fungi	:Chicago, Ill.	:Yes : 3-F-12
MQ 2-97	:Proteolytic enzymes in relation to market decay	:Belle Mead, N.J.	:Yes : 3-F-15
MQ 2-98	:Grapefruit and oranges in controlled atmosphere storage	:Pomona, Calif.	:Yes : 1-C-2,3
		:Harlingen, Texas	:
MQ 2-99	:Controlled atmospheres storage for stone fruits	:Beltsville, Md.	:Yes : 3-C-2,3
		:Wenatchee, Wash.	:
MQ 2-100	:Components of citrus rind affecting decay organisms	:Orlando, Fla.	:Yes : 1-E-3
MQ 2-101	:Infection of table grapes	:Fresno, Calif.	:Yes : 3-F-2
MQ 2-102	:Ozone on fruits and vegetables	:Beltsville, Md.	:Yes : 3-F-9
			: 12-F-5
MQ 2-103	:Development of mycotoxins in peanuts and rice	:College Sta., Tex.	:Yes : 4a-B-2
			: 6-B-3
MQ 2-104	:Heat treatments to control decay of fruits	:Beltsville, Md.	:Yes : 3-F-3,5, 6,8
			:
MQ 2-105	:Controlled atmosphere storage of ornamentals	:Fresno, Calif.	:Yes : 11b-A-1
		:Beltsville, Md.	: 11b-B-1,
			: 2,3
			: 11b-C-1
MQ 2-106	:Storage temperatures for vegetable salad oils		:No
MQ 2-107	:Quality of peanuts as affected by handling	:Raleigh, N.C.	:Yes : 6-B-4
		:Beltsville, Md.	:
MQ 2-108	:Storage effects on molds and aflatoxins in cottonseed	:Beltsville, Md.	:Yes : 7-B-3
		:Washington, D.C.	:
MQ 2-109	:Post-harvest microflora and effect on tobacco composition	:Hyattsville, Md.	:Yes : 11-B-1
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Work & Line Project Number	:	Work and Line Project Titles	:	Work Locations During Past Year	:	Line Project Summary of Progress	Incl. in Area and Subheading
MQ 3	:	Basic research on quality evaluation and development of objective measurements of quality factors in agricultural products	:		:		
	:	Program Leadership	:	Hyattsville, Md.	:		
MQ 3-3(C)	:	Quality indicators for stored wheat	:	Beltsville, Md.	:	Yes	:4-A-1
MQ 3-13 (C)	:	Relation of spinning performance of cotton to color grade*	:		:	No	:
MQ 3-14 (C)	:	Quick dye methods for determination of protein content of milk*	:	Beltsville, Md.	:	Yes	:2-A-1
MQ 3-15	:	Evaluating quality of tomatoes for processing*	:	Beltsville, Md.	:	Yes	:12-A-2
MQ 3-16 (R)	:	Determining the degree of milling of rice	:	College Sta., Tex.	:	Yes	:4a-A-1
MQ 3-17	:	Relation of cotton fiber properties to yarn strength	:		:	No	:
MQ 3-18	:	Detection of damage by heat in artificially dried corn*	:		:	No	:
MQ 3-20 (C)	:	Seasonal changes and metabolic activity of oranges*	:	Orlando, Fla.	:	Yes	:1-A-1
MQ 3-21 (CR)	:	Mechanization of seed purity analysis	:	Beltsville, Md.	:	Yes	:4b-A-1
MQ 3-22 (C)	:	Disease syndromes of market poultry*	:	Beltsville, Md.	:	Yes	:10-A-1
MQ 3-23	:	Determination of moisture in grain, seeds, and oilseeds*	:		:	No	:
MQ 3-24	:	Equipment for sampling and grading small grains and oilseeds	:	Beltsville, Md.	:	Yes	:4-A-2
MQ 3-25	:	Oil quality changes in long term storage	:	Washington, D.C.	:	Yes	:6-A-3
MQ 3-26 (C)	:	Defect evaluation of peanuts*	:	Beltsville, Md.	:		:
MQ 3-27	:	Quality measurement of red tart cherries	:	Raleigh, N.C.	:	Yes	:6-A-2
MQ 3-28	:	Quality measurement of apples	:	Beltsville, Md.	:	Yes	:3-A-3
	:		:	Wenatchee, Wash.	:		:3-A-1,2
MQ 3-29	:	Methods and equipment for grading farmers' stock peanuts	:	Raleigh, N.C.	:	Yes	:6-A-1
MQ 3-30	:	Lighting system for grain inspection	:		:	No	:
MQ 3-31	:	Assessing the sanitary quality of commercial egg solids	:		:	No	:
MQ 3-32	:	Seed metabolism	:	Beltsville, Md.	:		:4b-A-2
MQ 3-33 (C)	:	Effects of production, harvesting, and ginning practices on spinning performance and cotton quality	:	Clemson, S.C.	:	Yes	:7-A-1,2
MQ 3-34	:	Evaluating market quality of livestock and meat	:		:		:
MQ 3-36	:	Measurement of flour yielding capacity of wheat	:	Beltsville, Md.	:	Yes	:5-A-1
MQ 3-38	:	Maturity determinations in Italian prunes	:		:	Yes	:4-A-3
MQ 3-39	:	Physical techniques for determining purity of grass seeds	:	College Sta., Tex.	:	No	:4b-A-3
MQ 3-40	:	Determining susceptibility of potatoes to bruising	:	E.Grand Forks, Minn.	:	Yes	:9-A-2
	:		:	Presque Isle, Me.	:		:
MQ 3-41	:	Rapid method for determining moisture of hay	:		:	No	:
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*Discontinued during reporting year
**Initiated during reporting period

Line Project Check List -- Reporting Period July 1, 1964 to June 30, 1965

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Project Summary of Progress	Incl. in Area and Subheading
	Foreign Agricultural Research Projects Under Sections 104(a) and 104(k) of Public Law 480.			
A7-AMS-6 (k)	Post-harvest diseases of tropical and subtropical fruits	Allahabad, India	Yes	1-E-4
A7-AMS-12 (a)	Studies in the "Canary Coloration" of raw wools	Delhi, India	Yes	8-A-1
A7-MQ-1(a)	Resistance to stored grain pests in wheat**		No	
A7-MQ-2(a)	X-ray analysis for standardizing techniques in seed testing**		No	
A7-MQ-3(a)	Physiology of the khapra beetle with emphasis on fat metabolism**		No	
A7-MQ-7(a)	<u>Aspergillus flavus</u> and the role of aflatoxin in its metabolism**		No	
A10-AMS-4 (a)	Effects of ethylene dibromide on animals	Rehovoth, Israel	Yes	4-C-5
A10-AMS-7 (a)	A rapid test for protein value of grain and feeds		No	
A10-AMS-11 (k)	Environmental conditions and population dynamics of the khapra beetle	Jerusalem, Israel	Yes	4-C-2
A10-MQ-1 (a)	Germination inhibitors in seeds**		No	
A10-MQ-2 (k)	Maturation and ripening of avocado fruits**		No	
A10-MQ-5 (a)	Invisible marking of seeds**		No	
A22-AMS-1 (k)	Odor measuring instrument for grading foods		No	
E8-AMS-1 (a)	Studies of pesticide residues*	Helsinki, Finland	Yes	3-F-13 13-F-2
E8-AMS-5 (a)	Effects of various concentrations of carbon dioxide and nitrogen on refrigerated meat.	Helsinki, Finland	Yes	5-C-1
E8-AMS-6 (a)	Effects of pesticides on storage properties	Helsinki, Finland	Yes	3-E-4
E9-AMS-4 (a)	Fiber maturity and breakage in processing cotton	Rouen, France	Yes	7-A-6
E9-AMS-5 (a)	Instrument for homogenizing and orienting cotton fibers	Rouen, France	Yes	7-A-7
E10-AMS-3 (a)	Antimicrobial action of biphenyl on citrus fruit pathogens	Munich, Germany	Yes	1-E-5
E10-MQ-1 (a)	Maintaining germination of seeds for long periods**		No	
E10-MQ-3 (a)	Factors affecting physiological maturity of grass seeds**		No	
E15-AMS-2 (a)	Rots of apples and pears	Bologna, Italy	Yes	3-F-14
E15-AMS-4 (a)	X-ray research applied to fruit pathology*		No	
E15-AMS-8 (a)	Insecticide residues on wheat during processing and cooking*	Rome, Italy	Yes	4-C-4
E15-AMS-9 (a)	Insect infestation of spaghetti, macaroni, noodles, and other pastas	Rome, Italy	Yes	4-C-1
E15-AMS-12 (a)	Long term storage of edible vegetable oils	Florence, Italy	Yes	6-B-5
E19-AMS-8 (a)	Length properties and processing performance of cotton	Delft, Netherlands	Yes	7-A-8

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